

New Scientist

WEEKLY November 7 - 13, 2015

CRAWLY GLORY

How insects came to rule the world

COUCH SURFING

When psychiatry works better online

SIGHT TO SOUND

Glasses that let you hear your way

POLICE ACADEMY Why cops are taking science lessons to fight crime

ENTANGLED UNIVERSE

Wormholes and black holes are all mixed up



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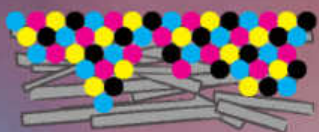
EVOLUTION OVERDRIVE How climate change rocked the cradle of humanity

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A black and white portrait of Professor Dame Carol Robinson, a woman with dark, shoulder-length hair, smiling slightly. She is wearing a dark V-neck top with a small brooch on the left side.

Professor Dame Carol Robinson

2015 Laureate for United Kingdom

By Brigitte Lacombe



Science needs women

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Dame Carol Robinson, Professor of Chemistry at Oxford University, invented a ground-breaking method for studying how membrane proteins function, which play a critical role in the human body.

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OEL SARTORE, NATIONAL GEOGRAPHIC PHOTO ARK/
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The Cambridge Executive MBA

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Counter-intelligence

Surveillance bill highlights UK government's scientific illiteracy

BRITAIN'S spooks are normally a shy and retiring bunch. So it was a surprise to see them throw open their doors to the media over the past week. What was the occasion? Cynics suggested it was a charm offensive to drum up support for the Investigatory Powers Bill due to be read in Parliament this week.

The bill, dubbed a "snooper's charter", is intended to legitimise the surveillance regime revealed by Edward Snowden – run in the UK from GCHQ's base near Cheltenham, which *New Scientist* also visited recently (24 October, p 10). As we went to press, the precise content of the bill was still under wraps. But even its outlines are worrying.

The bill proposes that internet service providers (ISPs) store everyone's web browsing history for 12 months, accessible by the security services, police forces and tax collectors. Claims this can be done non-intrusively are nonsense: such metadata are inherently sensitive. People who think they are being watched behave differently. And given the recent massive hack of TalkTalk, one might doubt the ability of ISPs to keep such data safe.

The UK government – along with the US, Canada, Australia, and New Zealand, its peers in the "Five Eyes" alliance – argues that

such risks are worth taking because it will help them to fight terrorism. The problem, of course, is that the evidence that might help us judge whether it really will is secret: so we are simply asked to trust they will do the right thing.

Even if you are minded to extend such trust, the bill remains worrying, because it shows little grasp of technological reality. The path to the new bill began with

"David Cameron's pledge to ban encryption would have made online commerce impossible"

prime minister David Cameron's pledge to ban encryption, thus leaving no "safe spaces" where terrorists could hide.

Unfortunately, that would also have made online commerce impossible, so has been watered down to a requirement that firms provide access to unencrypted communications. That would merely outlaw vastly popular encrypted services like WhatsApp.

This is still unworkable. Anyone with a little technical know-how can download or even write software to send encrypted messages without using a service provider. The maths on which the technology is built cannot be legislated out of existence.

The government also seems to think it can legislate chemistry. Its Psychoactive Substances Bill proposes to ban any substance that alters mental state. Taken at face value, that's everything from chocolate to flowers. As the deep absurdity of this has sunk in, the government has drafted a list of exempt substances. Homeopathic pills will be on it, we are assured: caffeine products are fine, too, as long as they contain both caffeine and, somehow, "no psychoactive substance".

This pattern of ill-conceived pledges followed by impractical legislation looks ominously as though it will be repeated in energy and education. That suggests the government is either scientifically illiterate or believes it can get its way by assuming its citizens are. Perhaps it can. Its ideological stances on terrorism and drugs may win wide support even if they don't make sense.

But pity those charged with enforcing the flawed laws that result. As it happens, police forces are mounting rigorous trials to find out which interventions are actually effective at reducing crime (see page 10) – a far cry from a reliance on gut instinct. It is a pity those making the laws don't seem to share that willingness to try thinking before they act. ■

Indonesian forests blaze

IT'S a health disaster in terms of dangerous air pollution. It's an ecological disaster in terms of the loss of habitat for threatened species like the orangutan. And it's a global disaster in terms of releasing massive quantities of carbon dioxide.

Tens of thousands of fires have raged in Indonesia this year, largely on Sumatra, in Papua and in the Kalimantan region of Borneo.

The fires have emitted 1.6 gigatonnes of CO₂ so far, says Guido van der Werf of the VU University in the Netherlands, who works on the global fire emissions database. To put that in perspective, it has been estimated that the entire world must emit less than 1000 Gt of CO₂ from 2011 onwards if we are to avoid dangerous warming.

CO₂ from wildfires is normally taken back up again as plants regrow. But this won't be the case in Indonesia, because the fires are also burning peat that has accumulated over thousands of years, releasing buried carbon. "You can assume that almost all CO₂ emissions [from the fires] will stay in the atmosphere," says van der Werf.

Forest fires blaze every year in Indonesia, but they burn most fiercely in El Niño years, when the region is drier. The good news is that this year's El Niño looks like it won't be anywhere near as bad as in 1997, when fires in Indonesia emitted over 4 Gt of CO₂.

Rain arrived on the island of Borneo last week, and the number of new fires detected has dropped substantially, so the worst may now be over.



ARQUES RANTE/GREENPEACE

Not good for the climate

A greener Oz

NEGATIVE emissions, as well as economic growth and improved biodiversity: Australia can have it all, if it really wants it.

According to a mammoth modelling study, Australia can continue to grow its economy by relying heavily on agriculture and mining, while also slashing emissions and improving the natural environment. But smart government policies will be key.

Researchers at CSIRO, Australia's government scientific research agency, combined nine

impacts (*Nature*, DOI: 10.1038/nature16065). Although such decisive action would weaken demand for its coal, the country would enjoy increased demand for its gas, uranium and agricultural produce instead – all things Australia can export in spades.

Even in scenarios where Australia achieved negative emissions as early as 2040, GDP still grows strongly in the models.

Planting forests turns out to be crucial for Australia to reduce its emissions, accounting for up to 40 per cent of its emissions reductions. Because much of that can be done using native plants, such a measure would also improve biodiversity.

The most positive scenarios for growth and climate are ones where carbon capture and storage becomes commercially viable.

"This is a landmark study," says Frank Jotzo at the Australian National University in Canberra. "Their findings should give Australia's politicians resolve to face up to the big questions of environmental sustainability," he says.

"This landmark study should give politicians resolve to face up to big sustainability questions"

different economic and environmental models to examine 20 different possible paths to 2050.

They found that strong international action on climate change would benefit the Australian economy, even ignoring the accompanying benefits of reduced climate

2°C rise inevitable

PREPARE for a world that's more than 2°C warmer.

The UN's analysis of what countries are offering to do to limit greenhouse gas emissions shows they fall far short of what's required. In fact, they suggest the world will have emitted enough carbon to warm the planet by 2°C as soon as 2036.

These offers will be the basis of the global climate change treaty to be finalised in Paris in December. It was always clear that

this treaty wouldn't go far enough to limit warming to 2°C by 2100, but now the numbers are in.

Even if the 146 countries stick to their targets, the UN concludes we will have burned 75 per cent of our carbon budget by 2030. Forecast emissions also suggest we would burn through the rest by 2036.

"I think it is clear [the targets] will fall well short of what is required for any reasonable probability of avoiding 2°C," says Alice Bows-Larkin of the Tyndall Centre for Climate Change Research in Manchester, UK.

Cassini takes the plunge

FLY-BY accomplished. Last week, NASA's Cassini spacecraft made its deepest dive ever through the spray of ice, vapour and salt erupting from the south pole of Saturn's moon Enceladus – and took incredible snaps to prove it.

As Cassini plunged through the moon's plume, it was going so fast that only the briefest of exposures were free of blurring. The probe also captured chemical data that, once analysed, will help us understand

whether the global ocean hidden beneath a crust of ice is a good place for life. Its views of the surface, combined with a record of the thickness of the plume from the fly-by, should tell us if the plume spurts from nozzles in the crust, or erupts sheet-like from cracks.

In one image, impact craters suggest that the surface here is fairly old. Elsewhere, huge grooves and ridges and the absence of craters indicate recent geological activity.

Arabian storm

YEMEN has been battered by the biggest tropical cyclone ever recorded in the country, which could bring three years' worth of rain in one day. This comes on top of the country's raging civil war.

"Eighty per cent of the population of Yemen needs some kind of humanitarian assistance"

As *New Scientist* went to press, Chapala had made landfall, hitting the city of Mukalla on Yemen's southern coastline, held by Al-Qaida. It is home to 300,000 people.

UN agencies began aid preparations last weekend, but expressed fears that Mukalla was ill-equipped to deal with the cyclone. "It doesn't have any local government, so our concern would be that normal disaster management provision will not be very effective," says Denis McClean of the UN Office for Disaster Risk Reduction.

Because Yemen's terrain is a solid sand crust, the rain cannot be soaked up, leading to flooding and mudslides. This can only worsen what is already a bleak picture for the country's citizens. "Eighty per cent of the population needs some kind of humanitarian assistance, so having a cyclone arrive at this time has been very unfortunate," says McClean.

EPA/STR



Wreckage from the Russian airliner

Plane downed

THE mystery continues. Days after a Russian airliner crashed on Egypt's Sinai Peninsula, investigators have yet to determine if the incident, which killed all 224 people on board, was the result of terrorist action or a technical failure of the aircraft.

The crash happened on 31 October, after the Metrojet aircraft, an Airbus A321, climbed out of Sharm el-Sheikh in Egypt on a flight to St Petersburg in

of 400 enthusiast-run radio beacons to listen for position and speed signals from aircraft. These indicated that flight 7K9268 went into a sudden and almost vertical descent before contact was lost.

That suggests an explosion of some kind. A flash of heat at the time of the accident, detected by a US spy satellite, might lend credence to that theory too.

"Investigators have yet to determine if the incident was the result of terrorist action or technical failure"

Russia. Twenty minutes later, close to its cruising altitude of 32,000 feet, flight 7K9268 suddenly disappeared from radar. Large fragments of the aircraft hit the ground soon after, creating a debris field 8 kilometres long and 4 kilometres wide. Investigators will now be looking for signs of a bomb as a possible line of enquiry, says Matthew Greaves, head of the Safety and Accident Investigation Centre at Cranfield University, UK.

The jet's flight-recorder information is yet to be analysed by investigators, but flight-tracking website Flightradar24 may have captured its last moments. The site uses a network

Martian planning

TIME to pack your bags? Last week, NASA held its first workshop to discuss where to send humans on the Red Planet, but some say we are far from ready for the trip.

NASA plans to land humans on Mars by about 2035. At the workshop, 45 groups suggested exploration zones that could offer scientific discoveries and resources. No decision was made, but it's a good start, says Melissa Rice of the California Institute of Technology in Pasadena. "I still wouldn't bet more than \$20 that a 2035 mission to Mars is actually happening, but I at least believe NASA are serious about it."

Others are more critical. "This is an exercise in make-believe," says Robert Zubrin, founder of the Mars Society, which is dedicated to human missions to Mars. "It's a public relations exercise of pretending that we have a human Mars exploration programme."

60 SECONDS

Baby, baby

China has scrapped its one-child policy, allowing all families to have two children for the first time in 35 years. But experts predict this may not make much difference. China's biggest city, Shanghai, piloted a two-child policy in 2009, but so far there is no sign of a baby boom.

Which sex are yew?

The UK's oldest tree is undergoing a sex change. The Fortingall Yew, a tree estimated at up to 5000 years old in Perthshire, is considered male because it produces pollen, but has recently started sprouting red berries – something that only female yew trees do. Such sex changes have been observed before, but are rare.

Life off Earth

This week marks 15 years of uninterrupted habitation on the International Space Station. A three-man crew began a stint on the orbiting outpost on 2 November 2000, when it was just three modules bolted together. It has since grown to 15 modules and hosted 220 people over the years.

Gene threesome

The UK has sanctioned a law that allows the creation of babies with genes from three people. The law permits the use of a genetic-engineering technique that will enable a woman to give birth to a child without passing on debilitating mitochondrial diseases.

Delivery bots

Got something to send? Try a robot. Starship Technologies, a start-up founded by the same people as Skype, has built bots that can trundle along pavements to deliver packages. The robots can navigate cities on their own, stopping to cross the road and avoiding pedestrians at a speed of 6 kilometres per hour. Able to carry 18 kilograms anywhere in a 5-kilometre radius, Starship's robots will begin pilot operations in 2016.



Enceladus in close-up

NASA/JPL-CALTECH/SPACE SCIENCE INSTITUTE

Hot climate fired-up human evolution

Sam Wong

IT'S been called the cradle of humanity, but the significance of East Africa's Turkana basin in human history is still unclear. Now some ancient herbivore teeth are revealing the region's special climate around the time our genus *Homo* first appeared.

Turkana, part of the Great Rift Valley straddling Kenya and Ethiopia, has been a hallowed site for the study of human evolution ever since Maeve and Richard Leakey began uncovering fossils there in the 1960s. Ranging from *Australopithecus* to our own species, *Homo sapiens*, the most striking finds include Turkana boy, a *Homo erectus* fossil that is the most complete early human skeleton ever found.

But was Turkana a recurring site for major events in human evolution, perhaps because it was a humid refuge for our ancestors during particularly dry periods, or simply a good environment for preserving fossils?

Now the teeth of herbivores are helping to answer this question. By studying fossil teeth from across the region, Mikael Fortelius at the University of Helsinki, Finland, and his team have pieced together a record of the region's temperature and rainfall that goes back 8 million years – well before early humans first appeared.

Their data show that East Africa as a whole became drier between 3 million and 2 million years ago – the period when our genus *Homo* first emerged. But the Turkana basin began to dry out earlier.

Fortelius thinks the basin's early shift meant it could have acted as a "species factory". Since it was ahead of the trend, new species that evolved there were adapted for the drier environment

that later became widespread.

"Statistically, you would expect many species that evolve in an area that's ahead of its time to be more successful, on average, than an area that's lagging behind," he says. "It might mean that, in East Africa at least, the Turkana basin might have contributed a disproportionate amount of new biodiversity for the region."

Fortelius presented his research at a meeting to celebrate the 70th

"The drying out of East Africa coincides with the first members of the *Homo* genus in the fossil record"

birthday of Richard Leakey, held at the Royal Society in London last month. "I personally think it's a great idea," says Peter de Menocal at Columbia University in New York. "For the first time he's showing how unique the climate is in specific parts of Africa."

De Menocal has been using ocean sediments to reconstruct the history of Africa's climate. Fossil plankton layers correspond to more humid conditions, while silty grains of dirt indicate more arid grasslands, giving an idea of the average climate across a broad region of north-east Africa.

But Fortelius's use of teeth is far more specific, says de Menocal, allowing different areas to be compared. "If you want to understand how climate has changed where the fossils are actually found, that's the kind of approach you need," he says.

Fortelius looks at the cutting edges and height of herbivore teeth that were present at a certain time. Short teeth, like those of elk, suggest a humid environment with lush vegetation, while tall teeth, like those of horses, are suited to wear and tear from



GREATSTOCK PHOTOGRAPHIC LIBRARY/ALAMY STOCK PHOTO

INDONESIAN CAVE OF BONES

Africa isn't the only continent that's thrown up intriguing human fossils. In 2005, researchers discovered remains of the diminutive *Homo floresiensis*, nicknamed "the hobbit", in a cave on Flores Island, Indonesia.

The bones suggest a human only 1 metre tall, living as recently as 18,000 years ago – long after other early human species, including the Neanderthals, had disappeared.

But a decade later, controversy still remains over whether the hobbits were a separate species, or simply a population of unusually small *Homo sapiens*.

The only *H. floresiensis* skull found so far housed a brain as small as a chimpanzee's, leading sceptical researchers to contend that it belonged to a malformed *H. sapiens*

who had a disease impairing neural development.

To lay the debate to rest, more bones are needed, but so far researchers have drawn a blank. This could be because they have been looking in the wrong place.

But that could be about to change. In 2006, Michael Gagan at the Australian National University in Canberra and his team discovered that the hobbit cave had a hidden basement chamber. Inside they found some more recent animal bones and stone tools during their initial excavations.

He hopes that deeper, older layers will contain *H. floresiensis* bones. "Who knows what amazing ancient bones could be buried there?" says Gagan. Colin Barras

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Cradle of humanity

members of the *Homo* genus, along with *Paranthropus*, a group of hominins known for their robust skeletons and grinding teeth. *Australopithecus*, an older group, disappeared around the same time.

The specific role of the climate shift in these events is unclear, but it would have changed what foods were available. Carbon isotope data from fossil hominid tooth enamel show that *Paranthropus*'s diet was mostly derived from grasses, while the doomed *Australopithecus* almost exclusively ate plants that weren't so well adapted to hot temperatures. Early *Homo* species seem to have eaten a mixture of grasses and non-grasses.

Other incidences of human speciation, extinctions and migrations seem to overlap with periods of unstable climate, and some researchers have suggested that traits such as large brains and bipedality evolved to help our ancestors cope with changing climate. But inferring clear relationships between climate change and evolutionary events is fraught with difficulty, says Hélène Roche at the French National Centre for Scientific Research.

"The problem is that when you look in detail at what we have in the field, it's not so obvious," says Roche. It had been thought that the first stone tools were linked to a drying climate, but this year, Roche's team found tools in west Turkana that are 700,000 years older than any found previously. "Now we have to rethink everything," she says.

Bernard Wood at George Washington University warns against making assumptions about where evolutionary events happened from the location of fossils. "The problem is, the drunk looks for his keys under the lamp post because that's the only place he can see," he says. "There's an awful lot of Africa for which one doesn't have the same evidence for the same time." ■

chewing grit in a grass-based diet, indicating a dry climate.

"The evidence comes straight from the horse's mouth," says Fortelius. His team has previously used this approach to estimate recent global rainfall patterns, with the results closely matching actual rainfall measurements.

The evidence from the teeth supports the story that the broader region began to dry up 3 million years ago, as suggested by de Menocal's sea sediment work, and analysis of the isotope carbon-13, which is more abundant when plants adapted to arid conditions, like grasses, have been present.

"The drying is coincident with a lot of major events in human evolution," says de Menocal. It coincides with the appearance in the fossil record of the first



A good home?

Europa's buried ocean may punch through icy surface

FORGET drilling through ice to reach Europa's buried ocean - it might come to us. In a cracked region of Jupiter's frozen moon, salty ice unlike anything seen before has been spotted.

Europa has been a perennial favourite in the search for alien life, thanks to its probable subsurface ocean. NASA plans to send a probe to the moon to study its surface in the 2020s, but what we are learning in the meantime is making it an even more attractive destination.

Observations from the Galileo spacecraft, which visited the Jupiter system in the 1990s, found that the moon hosts an ocean covered in water ice. Sulphur and oxygen from volcanoes on the nearby moon Io also fall onto Europa's surface, where they combine to make magnesium sulphate. Now a new analysis has found an unidentified material that only shows up in fractured terrain. This could mean the buried ocean is breaching the surface.

The spectrum, or chemical signature, of the material has so far defied identification. "It looks like the spectrum of water ice except that it's distorted," says Patrick Fischer at the California Institute of Technology. The team hasn't been able to reproduce it using a library of known chemicals - although they can rule out sulphates, which researchers expected to see.

One possibility is an unknown blend

of potassium or sodium chloride. This would mean these regions are salt flats left behind when ocean water bubbled up and then evaporated (*Astronomical Journal*, in press). "We can guess that the spectrum we're seeing is probably evaporate deposits of salt left over from the ocean," Fischer says.

If the hidden ocean is seasoned with those chloride salts instead of the expected sulphate salts, then the ocean's overall salinity could be three times lower than thought, making it friendlier to life.

"Microbial life on Earth can live in high salt concentrations, but it comes at a cost," says Christopher Chyba at

"The possible salt make-up of Europa's ocean makes it look less challenging for microbes to live there"

Princeton University. "These new observational results make Europa look slightly better from the point of view of the origin of life on Europa and, should life actually exist there, slightly less challenging for microbes to live in the ocean."

If ocean chemistry is laid bare on the surface, we could see if any of the chemicals that fuel chemosynthetic ecosystems on Earth are present - improving the chances of finding ocean life. Joshua Sokol ■

Police academy: Back in training

Cops are taking to evidence-based policing, finds **Jessica Hamzelou**

IT SOUNDS elementary, but for the first time, UK police officers will be running their own scientific trials to discover which practices actually reduce crime.

In the past 50 years, just 110 randomised controlled trials of police practice have been conducted around the world. Now, the UK police and forces from several other countries are starting to overthrow convention and move forward with more evidence-based approaches.

For thousands of years, law enforcers have trusted their intuition and instincts. But one in every 26 police efforts to reduce crime actually have the effect of increasing crime, says Lawrence Sherman, director of the Institute of Criminology at the University of Cambridge. "To do things without knowing the consequences is to act unethically," he says.

Now, new police officers across the UK will be taught how to understand and implement scientific evidence in policing, and how to run their own experiments and trials – made possible in part by a £10 million injection of cash from the UK government and the Higher Education Funding Council for England. The US has also begun to push for a more scientific approach to policing with the recent launch of the American Society of Evidence-Based Policing (ASEBP).

Early results from several trials show that some common police practices are ineffective, or even

harmful, while others highlight ways to ensure that people are all treated fairly.

Police practice is littered with examples of good intentions gone wrong. Take, for instance, the "scared straight" programmes established in the US in the 1970s. The idea sounds simple: identify young people headed for a future in crime, take them to prisons and scare them into good behaviour.

"Research shows this actually increases the likelihood of young people offending in the future," says Rachel Tuffin, director of research and education at the UK College of Policing. While the UK has phased these programmes out, they are still popular in some US states.

"There's a lot of police practice that runs against the evidence," says Sherman. For example, he says, "prosecution of juveniles leads to an increase in repeat offending". Research suggests that restorative justice – in which an offender has to explain their actions to the victim – seems to be more effective. "Arrest kids,

"We've prosecuted people for thousands of years without testing our approaches"

perhaps, but don't take them through the criminal justice system," Sherman says.

Even arresting someone can have unrealised effects. Take, for example, police responses to call-outs for domestic violence.



ANDREW TESTA/PANOS

In one trial, police either warned people about their behaviour or arrested them. Sherman and his colleague Heather Harris studied the resulting impact. They found that the partners of suspects that had been arrested rather than warned were 64 per cent more likely to have died 23 years later.

"Stress-related diseases appeared to be accelerated," says Peter Neyroud, a former detective superintendent now based at the University of Cambridge's Institute of Criminology. "It's controversial. Police are being asked to do more about domestic violence, but 'doing something' is not as straightforward as it sounds."

Trailblazers in evidence-based policing also face another problem – how they and their colleagues learned their jobs. "Officers are experience-based rather than evidence-based, although that is changing," says

Neyroud. At least, it is in countries like the UK. The US is further behind, says Renée Mitchell, a police sergeant at Sacramento Police Department in California, and founder of the ASEBP.

Cultural shift

Part of the problem in the US is that responsibility for policing is a local issue. The lack of federal control means that little progress is made, says Sherman.

"There are 18,000 police departments in the US, and some of those consist of one man and a dog," says Neyroud.

Mitchell hopes the ASEBP will help change that. "There's a cultural shift that needs to happen," she says. For instance, many police officers have yet to learn that they can expect better outcomes when they treat suspects with respect. "I've



Policing is at a crossroads

trained cops in communication skills – they say they’ll use them on citizens but not suspects because it’s ‘not safe,’ she says. “We need to show cops they are safer when they treat people well – that punishment doesn’t begin with them.”

Mitchell will start by making existing research more accessible to police officers in the US. “My dream is to take every piece of police research and translate it into police-speak,” she says. She also hopes to encourage officers to team up with academics to test whether what they are doing actually works.

Randomised, controlled trials are the best way to test police practice, says Sherman. That means randomly giving suspects one of two different types of treatment, and observing the effects. It’s a controversial idea, says Neyroud. “People think it’s

ethically wrong to randomise the treatment of offenders, because everyone should be treated equally,” he says. “But we’ve prosecuted people for thousands of years without testing our approaches – the time has come



ADAM PATTERSON/PANOS

to challenge them.”

At any rate, given the record of prejudice and racial profiling within many police forces, randomising treatment may turn out to be the fairest thing to do, says Sherman.

Time for change

Research results are already starting to transform police practice. One highly researched idea that is becoming widespread is “hotspot policing” – targeting specific areas that are known to be at the greatest risk of crime. “Four to 5 per cent of locations account for 50 per cent of crime,” says Neyroud. Mathematicians have been developing equations to help police forces, such as the LAPD, identify these hotspots. “Police were just policing hotspots selected on opinion,” says Sherman. “It turned out they were completely different to those identified by technology.” He says these equations have been put to use in Trinidad over the past two years, and they’ve seen a 45 per cent drop in homicide as a result.

Research has also changed the way police conduct interviews. In the UK, police no longer do interrogations, says Neyroud, because they are more likely to elicit false confessions. Instead, they perform cognitive interviews,

which draw on psychology studies to enhance the recall of a victim or suspect. For example, interviewees are encouraged to recount their story in reverse order, because they are more likely to remember the most recent aspects. They are also encouraged to report every detail, no matter how trivial, since this is known to help trigger other more relevant memories.

Many aspects of policing are long-overdue a scientific assessment. For instance, stop-and-search practices are often in

“There are 18,000 police departments in the US, and some of those consist of one man and a dog”

the spotlight, with police accused of targeting ethnic minorities. London’s Metropolitan Police Service recently attributed a rise in knife crime to the scaling back of stop-and-search programmes. There is no evidence that is the reason, says Neyroud. “But it would be nice to know.”

Last month, the UK College of Policing launched the first controlled trial to find out if training helps officers overcome any unconscious biases they might have, and make the way they stop and search people fairer and more effective.

Another controversial issue in need of analysis is the use of tasers. “Are tasers useful at reducing the use of force or not?” says Neyroud. “A taser can be lethal under some circumstances.”

Other projects are assessing the use of body-worn cameras, how to improve police responses to cases of child exploitation and how to best deal with hate crimes.

It is still early days, but proponents of evidence-based policing are hopeful. “The ethics of policing haven’t yet developed to the point where you have to prove that something doesn’t cause harm before you do it,” says Neyroud. “We’re not quite there yet. But give us a chance.” ■

Crime hotspot, or sign of prejudice?

Best way yet to predict IVF success

WILL IVF work for you? A new calculator could give you the most accurate prediction yet of your chances of success.

Fertility doctors tend to base a woman's odds of IVF success on her age and ovarian reserve – the number of follicles available for fertilisation. With this information they can decide whether or not to recommend treatment – which can be expensive, as well as mentally and physically demanding.

But existing models for predicting the outcome of IVF are based on limited, outdated information, says Rima Dhillon at the University of Birmingham, UK. IVF techniques have changed considerably since these models were developed – embryos are grown outside the body for longer, for example. Meanwhile, a decade of research has highlighted many new factors that can affect the outcome, including a woman's weight, any previous pregnancies or miscarriages she might have had, the cause of infertility and how long a woman had been trying for a baby. Ethnicity also seems to play a role, although no one is

sure why that should be.

To create a model that encompassed all these factors, Dhillon and her colleagues combed through data from almost 10,000 women who had their first round of IVF between

2008 and 2012. The data was taken from a UK-wide chain of fertility clinics, in which a quarter of women had their treatment covered by the NHS, while three-quarters paid privately. IVF was considered a success if a baby was healthy one month after birth.

The team then tested their model's ability to predict the IVF outcomes of women who had attended the fertility clinics between 2012 and 2013 and found that it was correct 65 per cent of

the time (*Human Reproduction*, doi.org/8t7).

It's not clear how accurate current predictions are. For example, a 32-year-old may be told that women her age have a 33 per cent chance of IVF success on average, but should she have any additional problems, such as a history of miscarriage, it is up to the doctor to make a "best guess" at predicting how this will affect her chances.

Older models do need to be updated, says Roger Sturmey at Hull York Medical School in the UK. "IVF is no easy choice, so couples really should be given the best, most accurate information available," he says.

The new model is only based on women who are about to start their first cycle of IVF using fresh embryos. Such women are given hormone treatments to stimulate the production of eggs, which are then removed and fertilised with sperm in a lab. A healthy-looking embryo can then be implanted.

Virginia Bolton, a consultant embryologist at Guy's and St Thomas' Private Healthcare in London, says that couples should have more realistic expectations about IVF success rates, but isn't convinced couples with low chances will change their minds, even with an updated test. "If you're the one person it does work for, the statistics don't matter," she says. **Jessica Hamzelou ■**



Maybe baby

T. rex may have hunted after dark like an owl

IT'S already the dinosaur of nightmares – now it seems *Tyrannosaurus rex* might have been able to hunt after dark.

The eyes of *T. rex* face forward, giving them stereoscopic vision for seeking prey. Robert Bakker at the Houston Museum of Natural Science in Texas has found evidence that their ears might also have been

focused forward, like those of some modern-day owls.

For many years, Bakker puzzled over a shelf-like ridge at the back of *T. rex* skulls. Unlike ridges that functioned as muscle-attachment sites, this feature is smooth, implying that it had another purpose, he says.

Finally, he realised that the ridge runs from the eardrum, positioned towards the back of the skull, to the front of the dinosaur's cheek. "The most likely explanation is that there was an ear tube – an ear trumpet, if you will – that was concentrating hearing from the front," he says.

Resting on top of the ridge, this tube could have enabled tyrannosaurs to precisely pinpoint sounds directly in front of them. Dogs and cats do this by turning their external ears, but *T. rex* would have been more like some owls or hawks that lack external ears but use their feathers to channel sound from the front of their heads to their eardrums. This could have given tyrannosaurs the option to hunt in low

"The most likely explanation is that an ear trumpet concentrated hearing from the front"

light, says Bakker, whose team presented its findings at a meeting of the Geological Society of America in Baltimore, Maryland, this week.

It's a plausible idea, says Philip Currie at the University of Alberta in Canada. But the ridge could simply have been there to reinforce the bone against pulling from muscles attached somewhere else, he says.

To know for sure if the ear tube existed, we need skull fossils with intact skin. Well-preserved fossils with skin have been found in China, so Bakker is optimistic. "Sooner or later they'll get one," he says. **Bob Holmes ■**



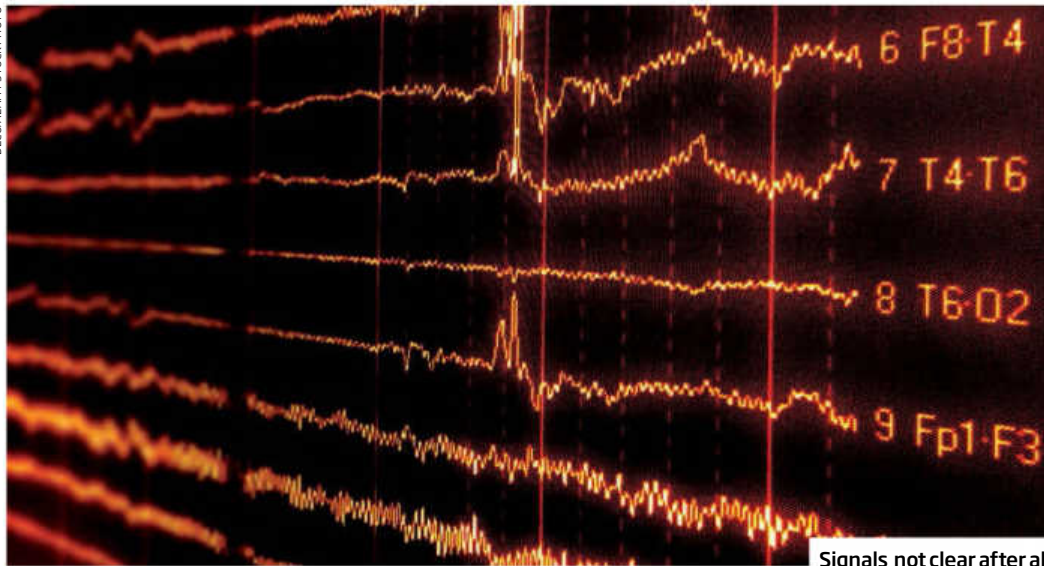
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Consciousness theory rocked

DOUBTS are emerging about one of our leading models of consciousness. It seems that brain signals thought to reflect consciousness are also generated during unconscious activity.

A decade of studies have lent credence to the global neuronal workspace theory of consciousness, which states that when something is perceived unconsciously, or subliminally, that information is processed locally in the brain.

In contrast, conscious perception occurs when the information is broadcast to a “global workspace”, or assemblies of neurons distributed across various brain regions, leading to activity over the entire network.

Stanislas Dehaene at France’s national institute for health in Gif-sur-Yvette and his colleagues are proponents of this idea. They discovered that when volunteers view stimuli that either enter conscious awareness or don’t, their brains show identical EEG activity for the first 270 milliseconds. Then,

if perception of the stimuli is subliminal, the brain activity peters out. However, when volunteers become conscious of the stimuli, there is a sudden burst of widespread brain activity 300 ms after the stimulus.

This activity is characterised by an EEG signal called P3b, and has been called a neural correlate of consciousness.

Brian Silverstein and Michael Snodgrass at the University of Michigan in Ann Arbor and

“This pushes us towards an explanation that connects neural dynamics to what it is like to be conscious”

colleagues wondered if P3b could be detected during unconscious processing of stimuli.

The study involved the oddball paradigm, in which one stimulus is presented frequently, interspersed with an oddball or rare stimulus. In other research the oddball stimulus prompted a stronger brain response.

The twist in the new experiment

was to ensure that all stimuli were entirely subliminal. Volunteers were frequently shown the word “LEFT” for 7 ms, immediately followed by a pattern that masked the word, preventing it from entering conscious awareness. Just 7 ms was long enough for the brain to unconsciously register the word, but too brief for the volunteer to say whether they saw anything. Occasionally, they were shown the word “RIGHT”, followed by a mask.

The rare stimulus produced a strong P3b signal, widely spread across the brain. “Even though they don’t know [what] the stimuli are, the brain is still able to recognise that there is something unexpected that occurs,” says Silverstein.

The team interprets the P3b signal as evidence for complex, sustained, unconscious brain activity, suggesting that P3b is not a neural correlate of consciousness, thus contradicting the global neuronal workspace theory (*Cortex*, doi.org/8v5).

Anil Seth of the University of Sussex, UK, says the study raises questions about neural correlates of consciousness. “It is pushing us towards more refined explanations that actually connect neural dynamics to what it is like to be conscious.” **Anil Ananthaswamy** ■

Molten metal storms rage on starless planet

WE JUST found weather on a lost world. Clouds of molten metal passing in and out of view could be behind the see-sawing brightness of a planet adrift in space.

The object, PSO J318.5-22, was discovered in 2013 using data from the Pan-STARRS telescopes in Hawaii, and is about eight times the mass of Jupiter. That makes it much more likely to be a giant planet than a small, failed star called a brown dwarf. It probably formed around a star and was somehow shot out of its orbit into lonely deep space.

Beth Biller at the University of Edinburgh, UK, and her colleagues measured the planet’s brightness and found that it could vary by up to 10 per cent in just a few hours. The explanation, they say, could lie in weather systems.

“If you think about the Great Red Spot on Jupiter, it would be stormy spots like that,” Biller says. But unlike Jupiter, which has cooled from a hot start over the long life of our solar system, this planet has a scorching surface temperature of about 1100 kelvin - maintained by internal heat since it has no star.

Under such conditions any clouds it has should be molten, containing liquid metals where on Earth we would have water (arxiv.org/abs/1510.07625). “These are likely hot silicates and iron droplet clouds,” Biller says. “This makes Venus look like a nice place.”

The team is now carrying out a similar analysis using observations of a star called HR 8799, which has planets much like this lone world.

The finding may mean that similar planets - whether orbiting stars or not - might show the same behaviour, says Caroline Morley at the University of California, Santa Cruz. “It strongly suggests that these objects should be variable [in brightness],” she says. “We really want to be able to look at this variability and then connect it to storm systems.” **Joshua Sokol** ■

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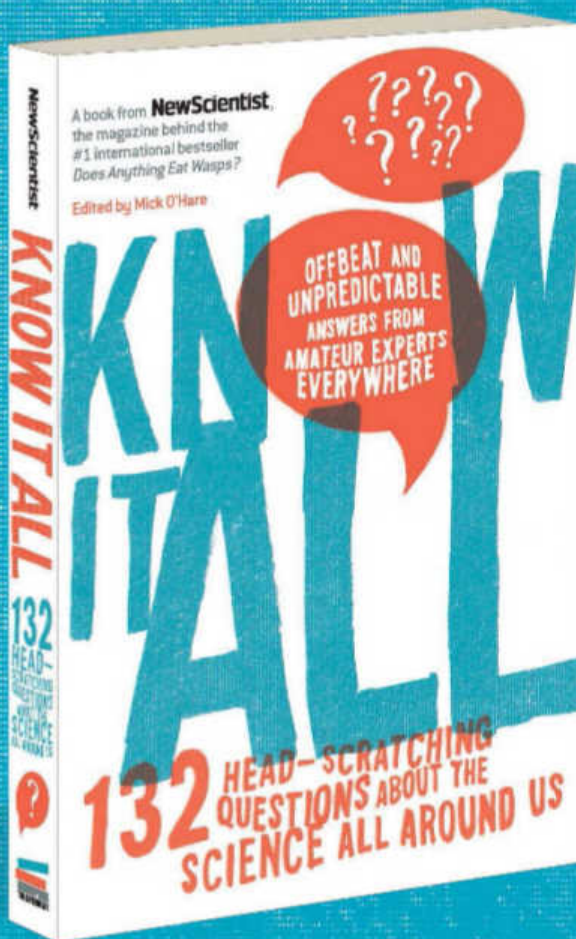
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Hitting on the right recipe to save world's heaviest parrot

THEY make an eccentric pair. The world's heaviest parrot – which also happens to be flightless – depends on the berries of a tall conifer tree for breeding, but the rimu tree can go for years without producing any fruit.

For decades, conservationists have been fighting to save the endangered kakapo, which lives on just a few small islands off New Zealand. Part of their strategy is to provide food supplements that can support breeding pairs when there are no rimu berries, but finding the perfect recipe has proven elusive. Too many calories, and too many male chicks hatch. Too much protein, and the

females stop eating before they have taken in enough calcium to make eggs. With only 125 animals left, getting the recipe right has been an urgent task.

Now Pamela von Hurst of Massey University in Auckland, New Zealand, thinks she has found the final essential ingredient: vitamin D. Kakapos are nocturnal and vegetarian, and blood tests revealed low levels of this vitamin. "Vitamin D is essential for absorbing dietary calcium and also plays an important role in the production of eggs," she says.

When her team analysed rimu berries, they found high levels of a particular form of vitamin D (*The Journal of Steroid Biochemistry and Molecular Biology*, doi.org/8vd). The finding could lead to a supplement nutritious enough to support breeding in fruitless years.

Mars is shredding beanbag moon Phobos

PHOBOS is being pulled apart. Grooves on the surface of Mars's largest moon suggest that the gravity of its parent planet is slowly tearing it to shreds.

We already knew that Phobos is doomed to destruction: the pull of Mars's gravity on its moon exerts tidal forces that are expected to rip it apart in tens of millions of years.

But Phobos is already showing

signs of wear. Previous observations showed long, often parallel grooves 100 to 200 metres long and 10 to 30 metres wide stretching across parts of it. They have also shown that Phobos is a pile of rubble held together by a stronger outer layer of dust 50 to 100 metres thick. That means the moon looks a bit like a beanbag: easily deformed, but held together by a covering.

Using that model, Terry Hurford of the NASA Goddard Space Flight Center in Maryland and colleagues calculated where the tidal forces would cause the most stress on Phobos, and found that the grooves are aligned with the regions of greatest stress.

"The grooves are the first sign of it tearing apart," Hurford says – although this could take millions of years. He presented the results earlier this week at a meeting of the Geological Society of America.

Crows swap tool tips over dinner

MEALS bring people together to mull over problems – and the same is true for crows.

New Caledonian crows are adept tool users, sculpting twigs to hook hidden food. To see how this skill might have spread, Christian Rutz at the University of St Andrews in the UK and his team used radio tags to track 42 wild crows.

They found that crows normally spent time nearest to close relatives, keeping their distance from other crow families.

But that changed when the team left them a log filled with inaccessible beetle larvae that could only be retrieved using tools. Then the segregation broke down and unrelated crows started associating, says Rutz.

Modelling showed that coming together in this way might explain how skills like tool use spread between unrelated crows (*Nature Communications*, DOI: 10.1038/ncomms8197).

Early death for the US middle-aged

A HEADY mix of booze, drug addiction and financial anxiety is dragging middle-aged people in the US to an early grave.

An analysis of causes of death has found that death rates for white US citizens aged 45 to 54 rose by about 0.5 per cent per year between 1999 and 2013.

People of the same ages in all other rich countries, as well as black and Hispanic US citizens, saw a 2 per cent fall in death rates over the same period (*PNAS*, DOI: 10.1073/pnas.1518393112).

Angus Deaton of Princeton University, who co-authored the study, suggests that liver disease, pension anxiety and the increased availability of addictive painkillers may all be to blame.

Breath sensor keeps pilots alert

IT'S the stuff of nightmares: a drop in cabin pressure on board your flight. The sudden decrease in oxygen leads to hypoxia, causing passengers and pilots to pass out. Now nervous flyers can breathe easier, thanks to a new device that warns pilots of the condition.

Although rare, sudden pressure drops do occasionally affect flights. An event like this was thought to have caused a plane crash in Greece in 2005, killing everyone on board.

Planes have oxygen-monitoring sensors, but that may not help if hypoxia has already started to affect a crew's flying ability.

Now a team from Wright-Patterson Air Force Base in Dayton, Ohio, has developed a real-time sensor to warn pilots of hypoxia. The sensor measures chemicals in exhaled breath called volatile organic compounds. By testing the sensor on volunteers during a simulation in which oxygen levels were cut, the team identified a VOC set that signalled the onset of hypoxia (*Journal of Breath Research*, doi.org/8vn).

The team aims to incorporate this technology into military aircrew masks to continuously assess pilot safety, says team leader Claude Grigsby. He says that biomarkers in breath could be used to monitor other aspects of health, such as fatigue, in commercial pilots too.

Feeling unwell, and lost your sense of smell?

YOUR sense of smell might be more important than you think. It could indicate how well your immune system is functioning, a study in mice suggests.

Evidence of a connection between the immune system and the olfactory system – used for sense of smell – has been building for some time. For instance, women seem to prefer the scent of men with different immune system genes to their own.

Fulvio D'Acquisto at Queen Mary University of London and his colleagues studied mice

missing a recombinant activating gene (RAG), which controls the development of immune cells. Without it, mice lack a working immune system and some genes are expressed differently, including those involved in the olfactory system. "That rang bells, because people with immune deficiencies often lose their sense of smell," says D'Acquisto.

His team measured how long it took mice to find chocolate chip cookies buried in their cages. Those missing RAG took five times as long as normal mice, and

failed to respond to other scents. Further study uncovered abnormalities in the lining of their noses (*Frontiers in Neuroscience*, doi.org/8vm).

D'Acquisto suspects olfactory cell survival might hinge on the presence of some factor released by immune cells. There could be an evolutionary benefit: "If you have a problem with the immune system, it would be a good idea to avoid exposing yourself to danger," D'Acquisto says. "Not smelling properly could encourage you to stay still."

Diminutive ancestor of all apes

DID great apes start small? A fossil primate found in Spain suggests the last common ancestor of great apes and gibbons might have been a lot daintier than we thought.

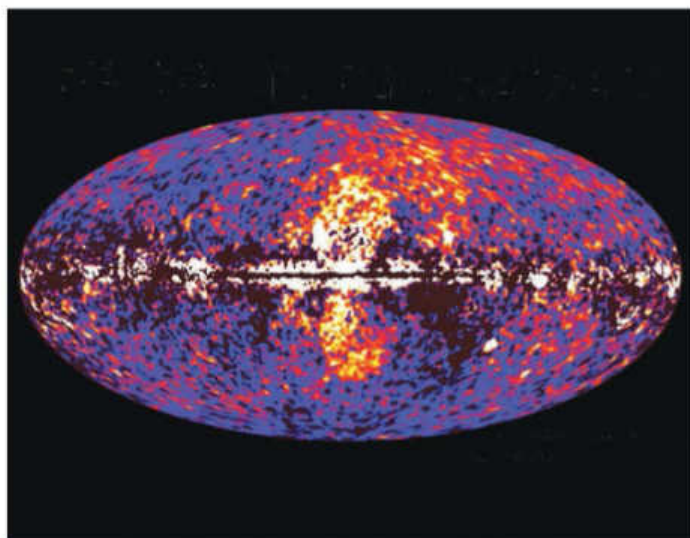
It had been assumed that our common ancestor was probably like *Proconsul*, which weighed about the same as a chimpanzee and lived in East Africa 23 million years ago.

But David Alba at the Catalan Institute of Palaeontology in Barcelona, Spain, and his team believe that the new find, *Pliobates cataloniae*, is evolutionarily closer to our split from gibbons.

The animal lived 11.6 million years ago and would have had a body mass of about 5 kilograms, roughly the same as a modern gibbon (*Science*, doi.org/8vp).

But the partial fossil's strange mix of features means not everyone is convinced. "For one thing, the elbow is just too primitive," says Brenda Benefit at the New Mexico State University in Las Cruces.

As well as lacking the bony elbow ridge that we share with gibbons, *P. cataloniae* also has a bony ear canal – a feature only seen before in a different, extinct group of primates.



Dark matter 'smoking gun' fizzles

HINTS that dark matter is crashing and burning in the centre of the Milky Way might themselves be going up in smoke.

An unexpectedly bright gamma-ray glow was first spotted at the centre of our galaxy in 2010, in data from the Fermi Gamma-Ray Space Telescope. Physicists interpreted it as the debris from particles of mysterious dark matter – thought to make up most of the stuff in the universe – crashing together and annihilating each other.

But this year, two teams found thousands of previously unnoticed

pulsars – corpses of dead stars – that could account for the brightness.

If the signal is down to dark matter it should be seen in other galaxies, such as dwarf galaxies. But when Kevork Abazajian at the University of California, Irvine, and colleagues analysed data from nearby dwarf galaxies, they found no such signal (arxiv.org/abs/1510.06424).

"If the dwarf limits were this strong in 2010-12 when we first started working on the dark matter interpretation of the galactic centre excess, we may have not taken it as seriously," he says.





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Air pollution – live online

Google is helping to map air quality in cities by attaching sensors to its Street View cars to produce pollution maps, says **Richard Schiffman**

WHAT do you do on days when the air doesn't smell right? Soon, you might just check Google Maps.

Google has teamed up with San Francisco-based sensor company Aclima and the US Environmental Protection Agency (EPA) to fit its Street View cars with environmental sensors. The cars will be used to produce up-to-the-minute neighbourhood pollution maps that could prove a lifesaver for people who suffer from asthma or other conditions that put them at risk when the air is bad. Air pollution kills an estimated 55,000 people every year in the US and 3.3 million worldwide.

Air quality is typically measured by stationary equipment scattered throughout a city: New York City, for example, has 17 monitoring stations. But widely spaced sensors have a

limited capacity to model the dynamic processes at work in an urban area, especially with wind, sunlight, humidity and traffic patterns shifting continuously.

The Google-Aclima project, by contrast, will move the sensors on to the streets. Cars fitted with mobile sensing equipment will criss-cross city neighbourhoods throughout the day to collect data about air quality. Algorithms will distil millions of readings for pollutants and greenhouse gases, including carbon monoxide, ozone and fine particulates, into colour-coded maps for the city.

Health warning

These real-time pollution maps will go live for residents in the San Francisco Bay area on Google Earth Engine, a geospatial analysis platform, early next year. Website

visitors will be able to see which pollutants are moving through their neighbourhoods or heading their way. California's Central Valley and Los Angeles will get their own maps later in the year.

Epidemiologists will be able to use the data generated to correlate, for example, the timing of asthma attacks or admission into hospital emergency rooms with air quality in a particular location at a given time, says Melissa Lunden, director of research at Aclima. "The health community is very interested," she says. The data should also help meteorologists model how air moves and diffuses through the concrete canyons of cities, says Lunden.

This is not the only project that aims to track pollution on the web. HabitatMap, a non-profit organisation in New York, has

introduced a pollution-mapping app that doesn't depend on cars roving the streets, but on pedestrians gathering data. Walkers strap on the AirBeam, a palm-sized sensor that records exposure to tiny particulates in the air as people move through the city. It sends that information to the AirCasting smartphone app, which transforms it into maps and graphs that show pollution severity and that participants can access on their smartphones.

Backed by funding from New York's Department of Environmental Conservation, HabitatMap is currently working to calibrate AirBeam with the

"Neighbourhood pollution maps could prove a lifesaver for people who suffer from asthma"

state's air-quality monitors. It hopes that the information generated by citizen scientists will eventually be melded with the state's data to create a fuller picture of what is happening on the streets. It is all about getting the community involved, says Michael Heimbinder, director of HabitatMap. "They're connecting the dots when they are out there taking measurements, seeing for example how particulate levels spike when a subway car rumbles under the grates beneath their feet, or when a truck drives by."

Projects like these are going to help people make personal decisions, says Dan Costa, director of the EPA's air, climate and energy research programme: "Do I walk down Acorn Street or Elm Street? Am I going to let my kids play outside today?"

The revolution in low-cost portable pollution sensors will also prompt agencies such as the EPA to up their game, he says. "It's going to move government to provide information in a different way – information that is in real time, locally based and that people can actually use." ■



Something in the air

CHRIS STOWERS/PANOS

RALPH GRANT/GETTY IMAGES



Seeing you loud and clear

Smart glasses translate video into sound

BLIND people often substitute sound for sight, and some can even use echolocation to steer around objects. But it turns out that sound can be tailored to convey visual information. That phenomenon is now being used to help build better navigation aids for blind people.

Researchers at the California Institute of Technology in Pasadena have developed smart glasses that turn images into sounds users can intuitively understand without training.

The device, called vOICe (OIC stands for "Oh! I See"), is a pair of dark glasses with a camera attached, connected to a computer. It's based on an algorithm of the same name developed in 1992 by Dutch engineer Peter Meijer. vOICe converts pixels in the camera's video feed into sound, mapping brightness and vertical location to pitch and volume.

A cluster of dark pixels at the bottom of the frame sounds quiet and has a low pitch, while a bright patch at the top would sound loud and high-pitched. The way a sound changes over time is governed by how the image looks when scanned left to right across the frame. Headphones send the processed sound into the wearer's ear.

Caltech's Noelle Stiles and her

colleague Shinsuke Shimojo explain (*Scientific Reports*, doi.org/8v9) that mapping visuals to sound in this way reflects how we integrate data from different senses. Perceiving a rose, for instance, means experiencing more than just its colour – its scent, the texture of its petals and the rustle of its leaves all come into play.

Shimojo and Stiles set out to understand how people intuitively map objects to sounds. They asked sighted volunteers to match images (stripes, spots and natural textures) to sounds, while blind volunteers were asked to feel textures and select sounds that seemed to correspond to them. The pattern of choices directly

shaped vOICe's algorithms and seemed to produce an intuitive result.

Blind people testing the device for the first time were able to match the shapes to the sounds as often as those who had been trained – both groups performed 33 per cent better than by chance. But when the encoding was reversed, so that a high part of the image became a low pitch and a bright part of the image became a quiet sound, volunteers found it harder to match image to sound.

"This research shows it's not just important how much information you provide, but whether you provide it in a way that the person can intuitively make sense of," says Lone Fine at the University of Washington in Seattle.

"They are basically saying that the magic bullet is going to be finding an intuitive mapping system and not relying on training," she says.

Fine points out that there is a gulf between distinguishing patterns in a lab and using vOICe to observe and understand the real world. But she says the work could ultimately help design better vision aids. Traditionally, these have relied on training users to understand the patterns produced when devices convert vision to other stimuli. "It's much better to find something intuitive and easy to use," she says.

Stiles and Shinsuke are now using functional MRI data to analyse brain activity, looking for that intuitive mapping system. Olivia Solon ■



No training required

LANCE HAYASHIDA/CALTECH

ONE PER CENT



Uncannily real

A robot can look too human, and yet not human enough. Maya Mathur and her colleagues at Stanford University in California asked people to say how likeable they found 80 robot faces. As the faces shifted from robotic to more human, likeability scores went up, then plunged, then climbed back up again near the end. This is in line with the uncanny valley effect in which things that look almost lifelike can cause revulsion (*Cognition*, doi.org/8v4).

"They asked me, 'Are you the S.O.B. that shot my drone?' and I said, 'Yes I am.'"

William Merideth, arrested for shooting down a drone as it hovered over his garden in Kentucky

Time to refocus

Can't take a good photo with your phone? Help is at hand. Researchers at the National University of Singapore have built an automatic photography guide that helps you compose pictures as you take them. The software analyses the frame of a shot and suggests changes to pan, tilt and zoom to improve pictures. The system also uses GPS, time of day and landmark data from photos of the same scene on social media to guide you.

DPA PICTURE ALLIANCE/ALAMY

Lie-detecting algorithm can spot a guilty face

THINK twice before you tell that fib. Using transcriptions from courtroom videos, a computer has learned to predict if someone is telling a lie.

A machine learning algorithm trained on descriptions of defendants' faces during real trials, including that of Andrea Sneiderman (below) who was convicted of perjury, correctly identified truth-tellers about 75 per cent of the time. Humans managed just 59.5 per cent. The best interrogators can reach 65 per cent.

"We're actually pretty bad lie detectors," says Rada Mihalcea at the University of Michigan in Ann Arbor.

Mihalcea and her colleagues took 121 videos from sources such as the Innocence Project, a non-profit group in Texas dedicated to exonerating people with wrongful convictions. This is superior to simulated conversation because the speakers are more invested in what they are saying.

Transcriptions of the videos that included the speaker's gestures and expressions were fed into a machine learning algorithm, along with the trial's outcome. To hone it further, the team plans to feed in even more data.

Such a system could one day spot liars in real-time in court or at airport customs, says Mihalcea, who will present the work at the International Conference on Multimodal Interaction this month in Seattle, Washington.

Aviva Rutkin ■



Nothing but the truth, please



Now where did I put that study?

AI assistant trawls papers for hidden info

IT'S the proverbial needle in a haystack. The more information there is online, the easier it is to overlook the most important stuff. Now an automated tool has been set the Herculean task of mining every science paper it can find online to help researchers come up with new ideas.

Semantic Scholar, launched this week by the Seattle-based Allen Institute for Artificial Intelligence (AI2), can read, digest and categorise findings from the estimated 2 million scientific papers published each year. Up to half of these papers are never read by more than three people. The system aims to identify previously overlooked information and connections with other research.

"Our vision is of a scientist's apprentice, giving researchers a very powerful way to analyse what's going on in their field," says Oren Etzioni, director of AI2. A researcher will be able to ask what the literature says about middle-aged women with diabetes who use a particular drug, for instance.

The system works by crawling

the web for publicly available papers and then scanning their text and images. By identifying citations and references, Semantic Scholar can determine the most influential or controversial papers. It also highlights key phrases from similar studies, extracting and indexing the data sets and methods used by each researcher.

AI2 is not the only organisation intent on digitising and analysing the world's scientific discoveries. Meta, a big-data start-up in Toronto, Canada, announced

"Machines that help us filter information could increase the rate at which we find useful nuggets"

a similar service this week called Meta Science, which scans publishers' libraries and university websites to rank scientific papers. In 2013, a system using IBM's Watson AI technology, called the Knowledge Integration Toolkit (KnIT), mined 100,000 papers to successfully predict the interactions of a tumour-

suppressing protein. IBM says KnIT is now fully automated to work without human oversight. The Defense Advanced Research Projects Agency (DARPA) in the US is also working on technology, code-named Big Mechanism, to read all papers on certain types of cancer to help identify potential treatments. It is scheduled for completion by the end of 2017.

Kenneth Forbus of Northwestern University in Chicago, Illinois, is confident that such services will prove useful. "Machines that help us filter could increase the rate at which we find, if not diamonds in the rough, then at least useful nuggets," says Forbus. "One might miss something, but professors already routinely use graduate students and colleagues for the same service, so the risks are well-understood."

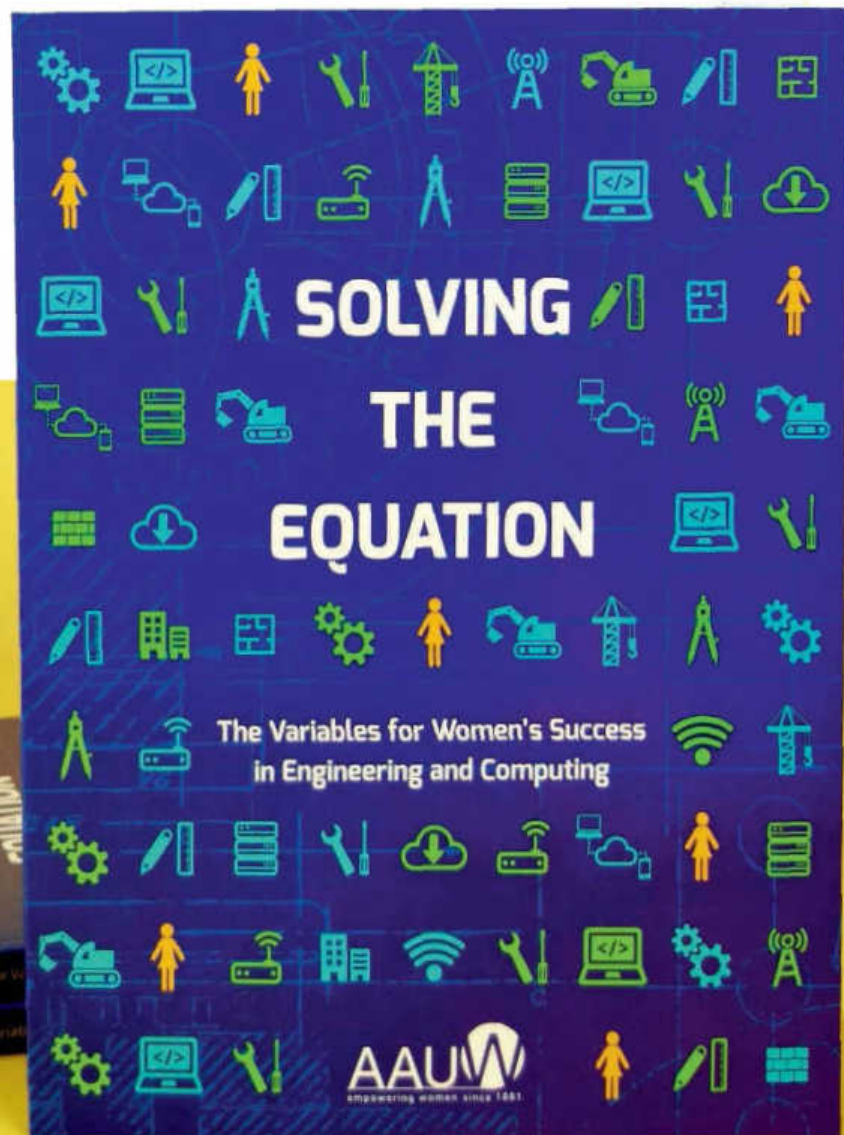
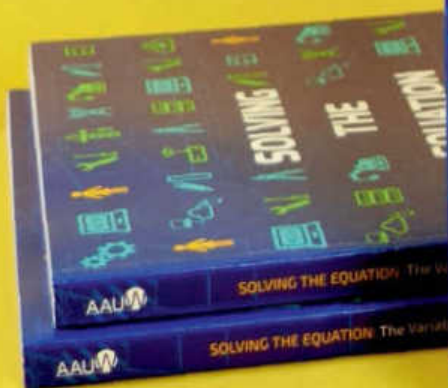
At launch, Semantic Scholar is focusing on computer-science papers. It will gradually expand its scope to include biology, physics and the remaining hard sciences.

Etzioni says the plan is to increase the system's power over time to see how deeply it can understand what a paper is about. "Ultimately, perhaps a human scientist doesn't have to read it at all." **Mark Harris** ■

Solving the Equation **started the conversation ...**

And now we're taking it one step farther. AAUW recently convened meetings with academic and corporate leaders to include their voices in the discussion of women's participation in engineering and computing.

Be the first to know the recommendations that came out of these important events. Visit www.aauw.org/newscientist.







Puddle mysteries

A SPOOKY forest, stripped of life by a natural disaster? Not exactly. Spanish photographer Fran Rubia snapped this scene on a trip to Iceland.

He set out to capture the colossal ice walls of the country's biggest glacier, Vatnajökull, which holds about 3300 cubic kilometres of ice. Instead, he fell for these branch-like formations in a puddle at his feet.

The photo covers an area about a metre square. The branches grow each day as the mud filters meltwater, then freeze in place at night. Rubia thinks the fineness, porosity and density of the mud combine with the slight slope to generate the patterns.

"It is a living pattern, a forest that continuously reshapes itself," he says.

The image was placed second in the "Nature's studio" category of the GDT European Wildlife Photographer of the Year 2015. Sam Wong

Photographer

Fran Rubia
franrubia.com

Cancer's final act?

Decades after declaring war on the disease, the US needs a second National Cancer Act to finish the job, says **Vincent DeVita**

SOME people believe that a lack of scientific progress is why we have not won the war on cancer. They point to the billions of dollars poured into research since the US government took on the disease via the 1971 National Cancer Act. And yet here we are, stuck in the trenches, they say.

The naysayers are wrong. Victory may be elusive, but not because the science is holding it back. I have seen the war from many angles: as researcher, clinician and director at the National Cancer Institute (NCI) in Bethesda, Maryland, as physician-in-chief at the Memorial Sloan Kettering Cancer Center in New York City, as director of Yale University's Cancer Center, as president of the American Cancer Society and, most recently, as a patient.

No, the real impediment in the war is the regulatory environment



and an outdated infrastructure for it, created well before we knew much about the disease.

As a result, outdated beliefs persist; bureaucratic battles erupt among physicians and medical groups; and the Food and Drug Administration (FDA) has yet to catch up with innovations in cancer drug development.

The National Cancer Act gave us the resources to amass the knowledge we now have. It also freed the research community to use its knowledge and tools efficiently, unencumbered by agency bureaucracies.

But it wasn't perfect. The draft act had called for the NCI, rather than the FDA, to approve cancer drugs as the institute better understood the issues, both scientific and practical. That didn't happen, and the FDA stands accused of being a roadblock for patients awaiting new drugs.

Martians first

Go all out with life-detection missions before putting boots on Mars, says **Jeff Hecht**

EVIDENCE that water still flows on Mars has raised hopes that the planet may support life. But those hopes mean different things to different people.

Astrobiologists see the findings as confirmation that Mars is the best hope in our solar system to host Earth-like life – so they want to keep it pristine as they search.

But advocates of crewed space flight see water as a boon to hopes of human exploration, a vital resource for a visit by astronauts.

Missions to the surface of Mars must abide by rules designed to avoid contaminating “special regions” that might sustain life. Anywhere with permanent or temporary liquid water falls into

that definition – the very places we want to check.

For the astrobiologists, sterilising robots for exploration can in principle reduce the contamination risk. But this is very difficult, and a further barrier remains: everything we have learned so far suggests that it won't be easy to detect life on Mars, and robots are inherently limited in what they can do.

Humans would be better able to look for evidence of life. NASA's

science chief has said as much, and the agency is busily talking up its ambition to get people there in the 2030s.

But a panel of the US National Academy of Sciences concluded recently that fully following planetary protection rules “may prevent humans from landing in or entering” special regions on Mars, because we carry microbes that could survive there.

It is a dilemma. Perhaps the best approach would be to start with an option that lies between the two camps. Robotic sample-return missions are no guarantee of a definitive answer to the life question, but analysis on Earth

“Sample-return missions would allow more detailed and powerful analysis on Earth”

Its superior understanding also won the NCI independence from the rest of the National Institutes of Health, but it has allowed this independence to be eaten away. The act also established cancer centres in universities, but they got embroiled in academic politics and fundraising battles.

So I say it is time for a new act, one that combines additional resources with the flexibility to untangle strangling regulation. It should allow NCI-funded centres to operate as independent NCI replicas, where research is done in concert with treatment. It would shift authority for early clinical trials from the FDA to the cancer centres. This would get new discoveries to patients much quicker. Finally, we need a cancer czar with control over the programme's budget.

If we do all this, we will soon see the end of cancer as a major public health issue. We have the critical mass of scientific knowledge; we need only to get around stifling regulations. The American people, who funded this war, deserve to see a victory. ■

Vincent DeVita is a professor of medicine, epidemiology and public health at Yale School of Medicine, and co-author of *The Death of Cancer* (Sarah Crichton Books)

would be more detailed and powerful than is possible remotely.

NASA has long proposed a mission to bring back rocks. No date is set, but its latest timetable calls for the Mars 2020 rover to stash samples. A return mission needs to become a top priority, with possible follow-ons depending on what is found.

Given the clamour to get people to Mars, trying to answer the life question before landing there is sensible. If that's not possible, the question will shape the agenda for the first visitors. ■

Jeff Hecht is a *New Scientist* consultant

ONE MINUTE INTERVIEW

Google's mind mission

Silicon Valley offers new ways to tackle conditions such as schizophrenia, says US mental-health expert **Thomas Insel**



PROFILE

Thomas Insel was director of the US National Institute of Mental Health (NIMH). Two months ago he left to join Alphabet, Google's new parent company. He is in the Google Life Sciences team, researching mental-health problems

Why did you leave the National Institute of Mental Health to work for Google?

I have to confess that after giving heart and soul to mental-health problems over the last 13 years working in government, I have not seen any improvement for either morbidity or mortality for serious mental illness – so I'm ready to try a different approach. If it means using the tools available in the private sector, let's go for it.

Are you saying Google is a better place to do mental-health research than the NIMH?

I wouldn't quite put it that way, but I don't think complicated problems like early detection of psychosis or finding ways to get more people with depression into optimal care are ever going to be solved solely by government or the private sector, or through philanthropy. Five years ago, the NIMH launched a big project to transform diagnosis. But did we have the analytical firepower to do that? No. If anybody has it, companies like IBM, Apple or Google do – those kinds of high-powered tech engines.

Will your new mental-health project mine Google's vast coffers of user data, the way Facebook does experiments on its users?

Probably not. I think there are such concerns around privacy and personal information that that would not be the place to start.

How can technology help find ways to end mental illness?

It can tell us things that are not obvious from our own eyes and ears. We can now think about using deep learning or intensive data analytics to study behaviour and cognition in a far more objective and precise way. Developing algorithms to decode early changes in speech could help us create devices to identify the early onset of schizophrenia. For example, a group at IBM used speech analytics to identify the first signs of psychosis. The team used machine learning algorithms to identify a particular pattern in the way words were connected. This subtlety hadn't been picked up by clinicians.

If you could talk to your younger self 15 years ago, how would you feel about Google and IBM carrying out mental-health research?

Even 15 months ago I wouldn't have imagined that we'd be having this conversation. Until very recently, the ecosystem was government funding and private-sector funding. "Private-sector funding" largely meant pharmaceutical companies. But today we're in a very different world. Public-sector funding has mostly been stagnant for the last decade. Now the private sector is expanding in some unexpected ways.

Will you have access to Google's big wallet?

I'm wondering that myself.

How did your colleagues at NIMH react to the news that you were leaving?

I gathered that there was a Twitter feed trending on the hashtag #takemewithyouom.

Interview by Sally Adee

For more on the use of technology in mental health, see page 40

Life on White Mars

Before we venture into deep space, we can learn a lot from studying a small group of people living in freezing isolation in Antarctica, says European Space Agency medic **Beth Healey**

You're at a research station in Antarctica, yet via Skype I can see you're wearing a T-shirt. I'll bet it's another story outside?

The lowest temperature was -81°C. If you add in wind chill, it can drop below -100°C. It's pretty chilly. It was a shock to the system when I arrived.

Sounds like a long way from civilisation...

I'm at Concordia, a French-Italian base high on the ice plateau, about 1000 kilometres from the coast. It was built 10 years ago because it's an ideal spot to drill for ice cores to examine past climate. Our closest neighbour is the Russian station Vostok, 600 kilometres away.

I've heard Concordia is sometimes called White Mars. Is that because it's a bit like being cooped up on a long space flight?

Yes. The European Space Agency, who I work for, also carries out experiments here. The isolation is one of the big reasons that the agency is interested in Concordia. In winter, you can go outside, but not for long.

So your compulsory confinement in winter mimics an extended trip to space?

There was a simulated space mission in Russia called Mars 500, which tested the effects of long-term isolation, but the participants could walk out of the door if anything happened. Psychologically, this is very different from somewhere like Concordia, where you know that even if you want to go, it's impossible.

How many people are at Concordia - and how long have you been cut off?

There are 13 of us. Apart from me, they are French, Italian or Swiss. We haven't seen any new people since February. For all nine of

those months we were totally isolated because of the temperatures. Even in an emergency, we couldn't have been rescued because it was too cold for planes to fly in because the engines don't work below -50°C. We've just got a few weeks left. The first plane is due any day now, depending on the weather.

So how was it being cooped up?

Better than I expected. When you arrive during the summer, you hear stories about things that have happened during the winter, that everyone's gone crazy and things like that. It hasn't been like that at all. Obviously, it is a linguistic challenge having the international component - the rest of the crew are mostly Italian or French. When people are tired in the middle of winter, the last thing they want to do is start talking somebody else's language.

You're one of the doctors on the base, but can you really do much in a medical emergency, in space or in the Antarctic?

On the International Space Station, if something happens, they only need to deal with acute problems and general life support before evacuating. On a long journey in space, where you don't have that option, space medicine will have to change. The model will be more similar to Concordia, where we have to deal with problems ourselves. Telemedicine will play a big part.

How will space medicine work?

It's a bit like Skype, only more sophisticated. On the operating table, HD cameras zoom in so doctors can see what you're doing remotely and in real time. You can have a direct line to different doctors, too.

PROFILE

Beth Healey is a doctor at Concordia base, Antarctica, run by the French Polar Institute and the Italian Polar Institute. At Concordia, she leads the medical rescue team and carries out research for the European Space Agency on the extreme environment's effects on the physiology and psychology of the crew



What else are you working on?

We're all slightly hypoxic on the station - there is a third less oxygen than at sea level because it's about as high as Mont Blanc. This lower-level hypoxia is what you might expect on a spaceship. One of my projects is to study acclimatisation to the lower oxygen levels.

Are you running cognitive tests to see what the experience is doing to you all?

Yes, we're doing a big experiment with the University of Pennsylvania. The ISS is also taking part, with astronaut Scott Kelly, who is



spending a year there. Every week, we do tests, looking at things such as general cognition, motor skills and short-term memory. Personally, my memory has been slightly affected. My sleep pattern has been all over the place. I was fine in 24-hour daylight, but when we lost the sun I was wide awake at 4 am and ready to fall asleep at lunchtime.

Did you have your brain scanned too?

Yes. We had functional MRI brain scans before we left for Concordia, and we're going to have them as soon as we get back, and then six

months after the mission. The scans will look for structural changes.

You've got a very fancy high-tech wristband. What's that for?

It's an activity watch – everyone in the crew is wearing these. They measure your general activity levels, and other things such as sleep patterns. The watch can tell who I'm in a room with and how close I am to them. It's looking at the relationships within the crew and how that changes, whether we are spending more time alone in our bedrooms or being more

sociable in the sitting room. It also looks at how my habits are changing over time – at how regularly I go to the gym and how long I spend working in my lab. I am also taking blood samples from us all to look at chemical markers for stress.

How do people cope away from normal life?

Some are much happier here than back in the “real” world, while others want to get home. It's interesting to look at the characteristics of different people and try to predict who would make a good crew for a long mission.

You have been recording video diaries. Why?

This is an experiment which has been running for a number of years here. We record a weekly video diary talking about our past week. The idea is to develop sophisticated techniques to interpret how an astronaut is coping and feeling during a space mission, beyond what they're actually saying. It looks at the frequency with which we're using certain word types – “team” words as opposed to “individual” words – and the tone and intonation of our voice.

“At Concordia, you know that even if you want to leave, it's not possible”

So a bit Big Brother-ish then...

Yes. There are a few Big Brother things. The psychological experience here is probably one of the most interesting aspects. Before we came, the European Astronaut Centre's human performance team trained us about living and working together as a crew, which is the same as they do with their astronauts.

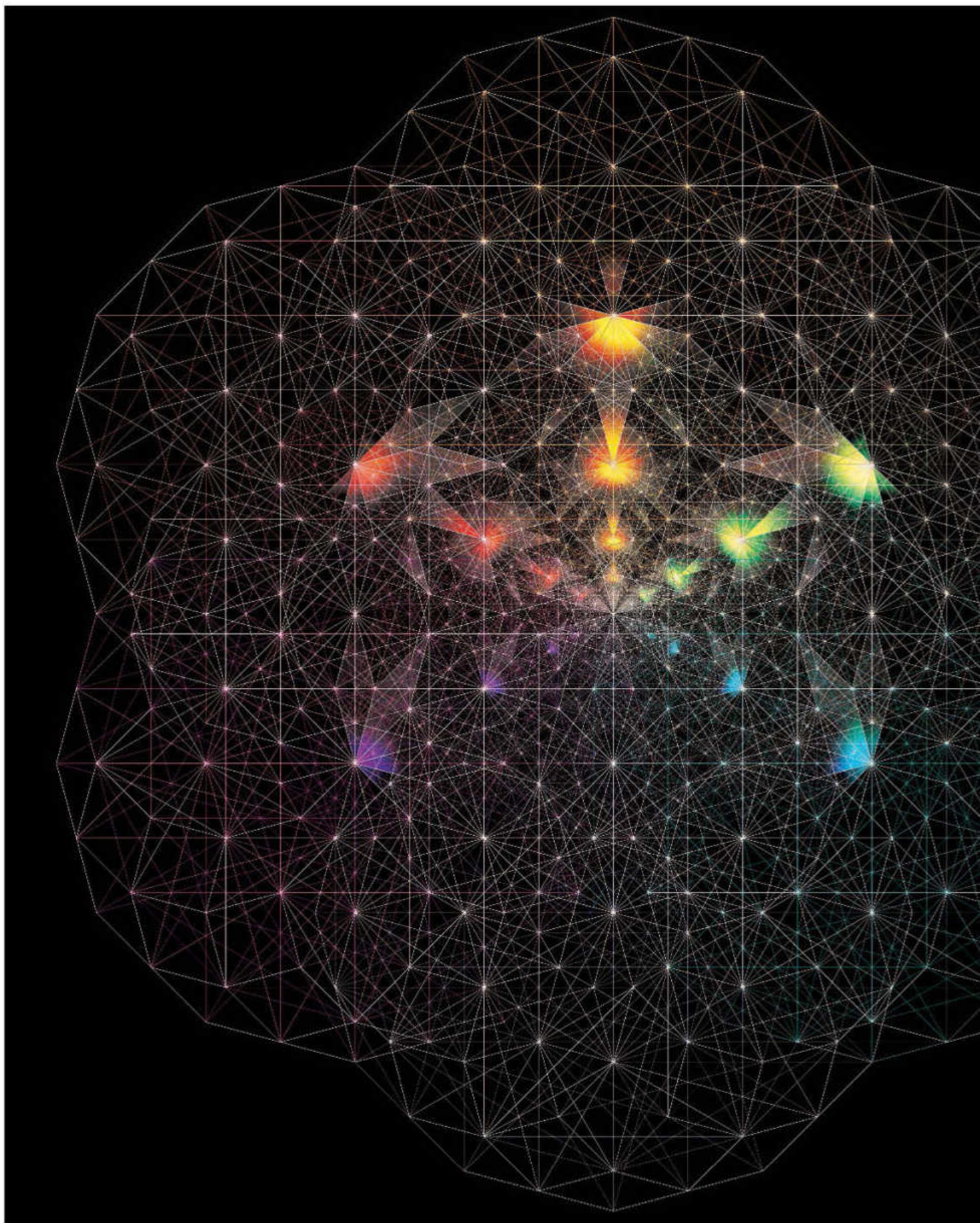
If there were a trip to Mars next year, would you sign up?

It depends if it's a one-way mission or not. I'd love to go to space, I'd love to go to the ISS, but I like Earth too much to give it up for good.

What are you most looking forward to when you get home?

We recycle all of our water and supplement it by melting snow here. It works really well, but you are not allowed to use normal shampoo or soap. So to be able to use normal shampoo, a good haircut, the little things... And of course getting back to see friends and family. That's definitely been the hardest part, being away from people. ■

Interview by Alison George



COVER STORY

ENTANGLED UNIVERSE

Might weird connections through space-time be the warp and weft of reality? **Anil Ananthaswamy** pulls at the threads

IT WAS a cryptic email that Juan Maldacena pinged across the US to fellow physicist Leonard Susskind back in 2013. At its heart lay a single equation: “ $ER = EPR$ ”. The message clicked with its recipient. “I instantly knew what he was getting at,” says Susskind. “We both got quite excited.”

Excited, because that one equation promises to forge a connection between two very different bits of physics first investigated by Albert Einstein almost 80 years ago. Excited, because it could help resolve paradoxes swirling around those most befuddling of cosmic objects, black holes, and perhaps provide a route to a unified theory of physics. Excited, because it might even answer one of the most fundamental questions of all: what is reality made of?

The origins of the story lie precisely a century ago. In November 1915, Einstein presented the final form of his revolutionary theory of gravity to the Prussian Academy of Sciences in Berlin. The general theory of relativity overturned notions of gravity that stretched back as far as Isaac Newton’s day. It said that everything that happens in the cosmos at large – be it an apple falling from a tree on Earth or the distant whirling of a cluster of galaxies – happens because stuff follows invisible contortions in space and time that are caused by the presence of other stuff. Gravity follows from the geometry of a warped space-time.

In the past century, general relativity has never failed an experimental test. Yet the suspicion has grown that it is missing something (*New Scientist*, 10 October, p 29). The theory describes space-time as a malleable yet smooth and featureless backdrop to reality. Problems start when a great

agglomeration of matter folds this cosmic fabric so tightly that a black hole singularity arises – an object with a gravitational pull so great that nothing can escape.

Black holes are a prediction from the earliest days of general relativity. But in the 1970s, physicists Jacob Bekenstein and Stephen Hawking derived a strange result about them: black holes have a temperature, and hence a property called entropy. This takes us into the realms of quantum theory where everything, be it forces or matter, comes in discrete chunks. Entropy measures how many ways you can organise a system’s various constituents – the arrangement of atoms in a gas, for example. The greater the number of possible configurations, the higher the entropy.

Hole in the theory

But if a black hole is just an extreme scrunching of smooth space-time, it should have no substructure, and thus no entropy. For Susskind, of Stanford University in California, this contradiction points to a hole in Einstein’s theory. “We know that general relativity is incomplete,” he says. “Its inability to account for the entropy of black holes is probably the most obvious incompleteness of the theory.”

That’s a turn up for the books. In his lifetime, Einstein levelled a similar charge at quantum theory. In May 1935, the *New York Times* ran a story with the headline “Einstein Attacks Quantum Theory”, reporting on a paper Einstein had written with Boris Podolsky and Nathan Rosen. It brought to light a weird property of the quantum world in which two particles could instantly influence each other, even if they were at opposite

PARADOX REGAINED: THE BLACK HOLE PROBLEM

In the 1970s, Stephen Hawking showed that black holes emit radiation. The mechanism has to do with quantum mechanics, which allows pairs of quantum-entangled particles to spontaneously pop into existence. When this happens near a black hole's event horizon, one particle may travel outwards, while the other goes towards the black hole. The result is a steady stream of outgoing particles, called Hawking radiation.

If no new matter falls into the black hole, this emission means the black hole will eventually evaporate. But matter is information, and in quantum theory information is sacrosanct: it can never be destroyed. So if a black hole evaporates, what happens to the matter, and therefore information, that fell into it?

One possible solution to this "black hole information loss paradox" is the idea that information escapes with the Hawking radiation. But in 2012, Joseph Polchinski and Don Marolf of the University of California, Santa Barbara, and colleagues showed this option creates other problems. General relativity demands that the space-time around a black hole's horizon should be smooth and featureless. It turns out that for this to be the case and for information not to be lost, a Hawking particle on its way in would have to be entangled with all other Hawking particles that left the black hole at all earlier times, rather than just its partner outside the horizon.

This offends a fundamental quantum rule known as "monogamy of entanglement" – that a quantum particle can only ever be fully entangled with one particle at a time. But if you break the polyamorous entanglement of Hawking particles, an energetic "firewall" of radiation forms at the event horizon. That, unfortunately, goes against the tenets of general relativity. Paradox preserved.

ends of the universe. In Einstein's view, this "spooky action at a distance" – quantum entanglement, as it became known – was preposterous. It was a clear sign there was something missing from the quantum description of reality.

But quantum theory has breezed through even more precise experimental tests than those devised for general relativity. And it is the very property that Einstein discovered – entanglement – that continues to expose the contradictions between the two theories. Allowing quantum entanglement and general relativity to cohabit in the contorted space-time around black holes yields unpleasant and unsustainable consequences. For example, information seems to be destroyed – an impossibility according to quantum physics – or the black hole becomes surrounded by a blazing "firewall" of energetic particles (see "Paradox regained", left).

So we need some way to square the two schools of thought – to quantise space-time and form a quantum theory of gravity. Susskind and Maldacena, who works at the Institute of Advanced Studies in Princeton, have long been leading lights in perhaps the most promising field with this aim: string theory. It replaces the point-like particles of current quantum theories with wiggling strings of infinitesimal size, and suggests space-time has a grainy substructure – you can't keep chopping it indefinitely into smaller and smaller pieces.

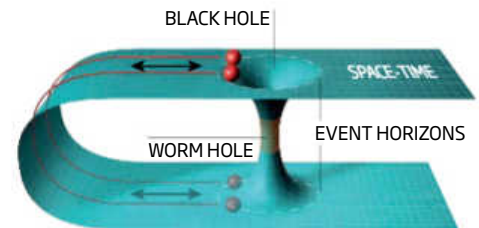
But if string theory does hold the answer, it's well hidden. The theory has more than 10^{500} solutions, each describing a different sort of universe – making it nigh-on impossible to find the one solution that corresponds to the geometrically flat, expanding space-time filled with the exact complement of fundamental particles we observe around us.

A startling insight from Maldacena in 1997 gave new hope. He conjectured that string theory equations describing gravity in some volume of space-time were just the same as a set of quantum equations describing the surface of that volume. If you could solve the surface equations, you could get a viable theory describing gravity inside.

This "Maldacena duality" was a bold leap – but physicists found that it held. "The funny thing was that it was not proven, and it was difficult to even understand why this was happening," says theorist Mark Van

Quantum web

The fabric of reality might be woven from quantum entanglement



"Wormholes" connecting two black holes in different parts of space-time can exist – but only if particles on the black holes' surfaces are **quantum entangled**

Raamsdonk of the University of British Columbia in Vancouver, Canada. "It was very mysterious."

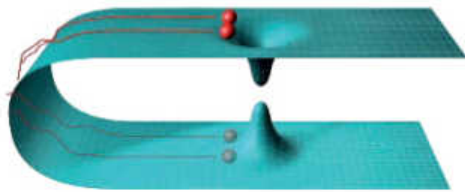
In 2001, Maldacena himself provided an intriguing example, going back to a paper written by – you guessed it – Einstein, again with Rosen, and again in 1935. This one exposed another peculiarity of black holes. It showed how something that looked like two separate black holes from the outside might be connected on the inside. This interior connection formed a shortcut through space-time, and came to be known as an Einstein-Rosen bridge – or in common parlance, a wormhole.

Quantum chewing gum

The really odd thing, though, was that Maldacena's duality showed that such a wormhole would only form if the outsides of the black holes were quantum-entangled.

By 2009, the underlying mathematics was sufficiently well developed for Van Raamsdonk to explore further. Entanglement is not an on/off thing – it can exist in varying degrees. So what would happen if you were to slowly reduce the amount of entanglement between the black holes' surfaces to nothing? The answer was rather like pulling at two ends of a piece of chewing gum. "The two sides get further apart, and what's connecting them is this really thin piece of gum, and eventually it snaps," he says. The wormhole becomes thinner until it breaks, and you have two unconnected bits of space-time (see diagram,

PARADOX LOST: THE BLACK HOLE SOLUTION



Break the entanglement, and the wormhole snaps too, suggesting entanglement is the thread that binds space-time together

above). Reverse the process – increase the entanglement – and the wormhole starts to form again.

It took a few more years for the penny to finally drop in Maldacena's mind, and for him to make the suggestion laid out in that excited email. ER = EPR. ER – the paper Einstein wrote with Rosen in 1935 introducing the concept of wormholes. EPR – the paper he wrote with Podolsky and Rosen the same year introducing the concept of entanglement. What if, asked Maldacena, wormholes and entanglement are in fact two sides of the same coin: the same physics in two different guises?

The immediate attraction was that the principle seemed to get rid of those pesky paradoxes involving firewalls around black holes (see "Paradox lost", right). But it also provided some form of explanation for the phenomenon Van Raamsdonk's work had exposed, in which space-time in the form of wormholes could be created and destroyed simply by tweaking the amount of entanglement.

"It's pointing to a statement that is really quite dramatic," says Van Raamsdonk. "Space-time is really just some geometrical manifestation of entanglement." Maldacena comes to the same conclusion. "There is a very close connection between quantum mechanics and space-time," he says. "The continuity of space-time, which seems to be something very solid, could come from the ghostly properties of entanglement." Susskind speculates further. Quantum entanglement is a form of information, and so "space-time

is a manifestation of quantum information", he says.

Heady stuff. But does that really mean that when quantum entanglement exists between two particles – as can easily be made to happen, say between photons in a lab experiment – they are connected by a microscopic wormhole? Or that we live on a backdrop that is nothing more than the 1s and 0s of entangled information?

The short answer is we don't know. One very big caveat is that all of the work linking entanglement with space-time so far has been done with a space-time that isn't expanding. Van Raamsdonk and others are working to extend the results to the sort of expanding, accelerating space-time that makes our cosmos.

But for those involved, this is the most positive lead yet towards a theory of quantum gravity that can unify the forces of nature. The ER = EPR principle is something "that a theory of quantum gravity should obey", says Maldacena. Susskind thinks so too. "We are sure that these things are going to be part of the final story," he says. "But I don't think we have a clear picture of what that final story is yet."

Others are less convinced. Joe Polchinski and Don Marolf are physicists at the University of California, Santa Barbara, and part of the team that exposed the black hole firewall paradox. Polchinski is concerned that the ER = EPR idea will end up modifying a central principle of quantum theory, known as superposition. Exemplified by Schrödinger's cat, this principle explains that a quantum system can exist in two different states at the same time. When quantum objects become entangled, they also enter a superposition.

At first glance, the ER = EPR hypothesis would mean quantum systems that become entangled, and therefore enter a superposition, suddenly gain a wormhole – a conjuring trick the superposition principle doesn't obviously allow. That's problematic, says Polchinski. "Quantum mechanics is weird, but it works," he says. "When you give up superposition, it's just weird."

Still, he remains open to the eventuality. "In the history of science, things that seemed absolute in many important cases have turned out to be not absolute," he says – Newton's law of gravitation, for example.

The main problem with the black hole paradox is the idea of quantum monogamy – a particle can only be entangled with one other particle at a time (see "Paradox regained", left). This means that three quantum systems – say a particle inside a black hole's event horizon, a particle outside it, and a third far, far away – can't all be entangled at the same time.

But physicists Juan Maldacena and Leonard Susskind argue that this can be resolved if the particles just inside the horizon and the particles far away are connected via a wormhole. When a wormhole connects two objects, one must lie to the future of the other.

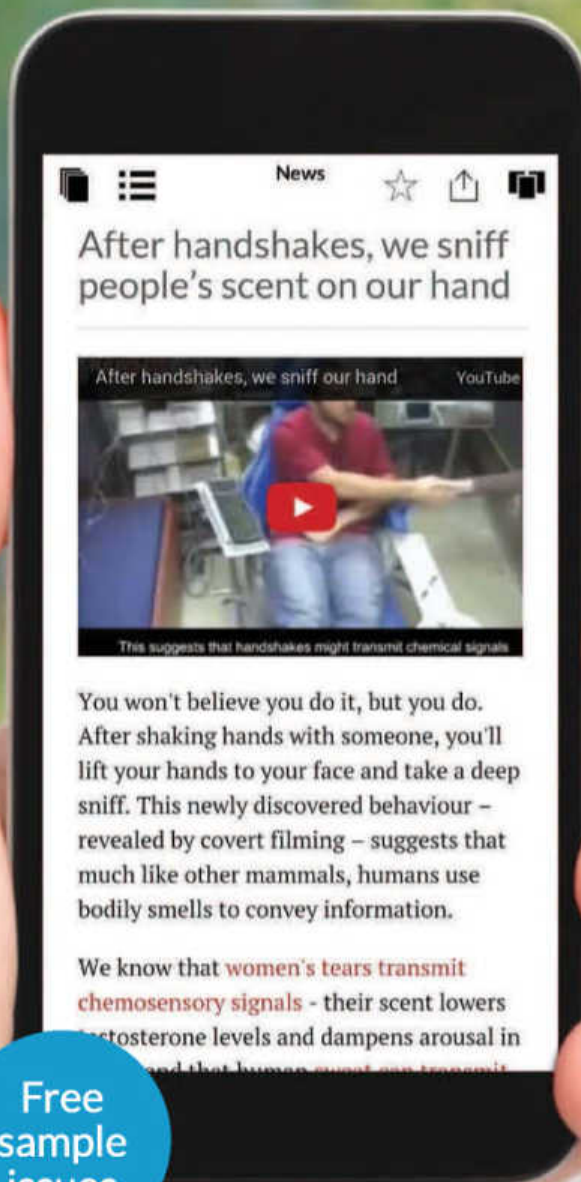
So, although these two particles might be entangled, their entanglement doesn't necessarily conflict with the entanglement of the particle inside the horizon and its immediate partner outside the horizon – because they aren't all happening at the same time. Uncomfortable apparitions such as blazing firewalls at the event horizon disappear. Paradox removed.

"Maybe superposition is one of them." Maldacena says that it's too early to say if their work is threatening the superposition principle, because the mathematics hasn't been worked out in detail.

Marolf for his part isn't convinced the ER = EPR equality works in all circumstances: Susskind and Maldacena have shown how to avoid the firewall only for a particular entangled state of black holes. "You might think that it shows how to get out of the [firewall] paradox for any highly entangled state, but that's not true," says Marolf.

Given that Einstein developed the ideas of both wormholes and entanglement, one can only wonder what he would have made of it all. "My guess is that the old Einstein would have said poppycock," says Susskind – after all, Einstein spent much of his later years arguing for a hidden reality that wasn't subject to the vagaries of quantum mechanics. "But the young Einstein apparently had a much more flexible mind. My guess [is] that the young Einstein would have embraced these ideas, loved them." ■

Anil Ananthaswamy is a consultant for *New Scientist*



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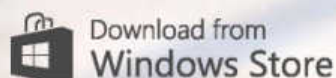
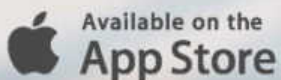


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Small wonders

It's not humans that dominate the world,
finds James O'Donoghue



BJÖRN VON REUMONT is in search of an oddity. The creature, a blind crustacean, 4 centimetres long and resembling an upside down centipede, is to be found in the watery depths of just a few sinkhole caves around the world – which is why von Reumont is in the ancient Mayan rainforest of the Yucatan in Mexico.

"It's like diving through Vaseline," he says, describing the strange sensation of crossing from the fresh surface water to the saltwater below. Some 25 metres down, he enters a narrow cavern filled with stalactites and sculpted rocks, and it's here, in this dark and alien world, that he spots his quarry. The animal swimming into view in the light of his lamp, searching for prey to impale with its venomous fangs, is a remipede. Although rare, it is not just another curio. Remipedes are the closest living relatives of the most successful creatures on Earth – the insects.

Three-quarters of all known animals are insects, a staggering 1 million species in total with an estimated 4 to 5 million yet to be discovered. By contrast, there are fewer than 70,000 vertebrate species. Harvard University entomologist Edward O. Wilson has suggested there may be as many as 10 quintillion insects alive at any one time – that's 10^{18} , or more than a billion for each person on the planet. They have colonised every continent, including Antarctica. They can live in air, land and water. They even live on us – lice evolved as soon as there was hair and feathers to set up home in. They are the kings of the arthropods – animals with hard exoskeletons – and the most successful group of animals that has ever lived. It's something we have long known, yet we are only now starting to understand how they have come to dominate.

Remipedes provide the first clue. Crustaceans are among the earliest arthropods,

This hickory horned devil embodies one the greatest insect innovations – metamorphosis

emerging in the Cambrian period, between 550 and 500 million years ago. The oldest insect fossil is some 410 million years old, but it's an elaborate creature, indicating that insects evolved much earlier. Their ancestors were once thought to be myriapods – land animals including millipedes and centipedes – but von Reumont, an evolutionary biologist from the University of Leipzig in Germany, and others had different ideas. In 2010, he published research suggesting that the closest living relatives of insects are the aquatic remipedes. Similarities in their brains, nervous systems and many of their proteins all point to an ancient common ancestor, he says. That would mean not just that insects evolved in the watery margins between sea and land, but also that they are much older than we thought.



The clincher came a year ago. “Scientists had been debating insect relationships for more than 200 years. It was clear that a new approach was needed,” says Bernhard Misof of the Alexander Koenig Research Museum in Bonn, Germany. So he and a team of more than 100 researchers carried out a huge genetic study of insect evolution and relatedness (*Science*, vol 346, p 763). This confirmed their watery origins. “Insects are terrestrial crustaceans,” says Misof. And they evolved about 480 million years ago, the study suggests, making them among the first things ever to walk on land. Around this time, the first terrestrial plants also evolved, which might have helped insects make the leap.

Whatever the spur, life on land came with formidable challenges, including dealing with dehydration, the effects of gravity, breathing air and daily extremes of temperature and solar radiation. A tough exoskeleton would

have helped, but it still probably took millions of years for truly terrestrial insects to evolve. Indeed, some of the most primitive species alive today, the jumping bristletails, still need moist soil to live in. But the land offered big opportunities too. There was plenty to eat and there were fewer predators to deal with than in the sea. Misof’s genetic study indicates that insect evolution really took off around 440 million years ago, with an explosion of species emerging. Then came a development that would take them to another level.

The oldest insect fossil ever found comes from the rolling hills around the village of Rhynie in Aberdeenshire, UK. Those rocks are teeming with tiny centipedes, mites, spiders and stubby plants, all petrified in the silica-rich waters of a volcanic hot spring around 410 million years ago. But in 2004, Michael Engel of the University of Kansas in Lawrence found something else. Examining one of the ►

“Blind, cave-dwelling remipedes are the closest living relatives of insects”





THERE BE GIANTS

Welcome to the Alice in Wonderland world starting in the Carboniferous some 320 million years ago, where familiar-looking insects reached scarily unfamiliar sizes. The dragonfly-like *Meganeuropsis*, or griffinfly, for example, had a wingspan of up to 70 centimetres. *Arthropleura* was a kind of millipede, but longer than a human. How could they grow so big?

One answer is oxygen. Plants had recently evolved the woody compound lignin and, with no decomposing organisms yet present to break it down, trees were being buried rather than recycled. As a result, oxygen levels in the air reached 31 per cent, half as much again as today. Insects breathe through tiny holes in their exoskeleton, which allow oxygen to reach their tissues directly via tracheal tubes. This set-up limits their size because eventually too great a proportion of their body needs to be given over to tubes. But that changes with more oxygen in the air. "Almost all insects develop smaller tracheae," says Jon Harrison of Arizona State University in Tempe, who has tested this in the lab. This allows them to grow bigger.

Gigantism was not to last, however. The maximum size of insects' wings reflected oxygen levels for 180 million years, according to Matthew Clapham of the University of California, Santa Cruz, but then something curious happened. By the time of the Cretaceous, between 145 and 66 million years ago, maximum wingspan had halved, even though oxygen levels rose. And what had evolved by then? Birds. "If birds weren't around, some insects might actually be much bigger today," Clapham says.



The rhino beetle – just one spectacular example of more than 400,000 types of beetle

fossils under the microscope he was gobsmacked to see tiny, perfectly preserved mouthparts of a type only found in insects, and not just any kind of insect. "This was our first peek at a flying insect," he says. Although its wings were not preserved, all the evidence indicated that *Rhyniognatha hirsti* was a relatively advanced flyer. This would make the origins of flight even earlier, perhaps at the species explosion 440 million years ago. The oldest fossilised insect wing is 324 million years old, so in one fell swoop, flight's evolution has been pushed back more than 80 million years. Misof's study supports the date.

Up, up and away

What got insects into the air? Engel suspects they were climbing the stems of plants bordering swamps to feast on spores, and found it easier to glide back down. Silverfish – primitive flightless insects living today – have a tiny pair of flat lobes extending out of their thorax, which they use for control when falling. And genetic analysis suggests wings evolved by the expansion of such lobes along with the development of hinges derived from the legs to control movement.

Insects were the first to evolve powered flight – and the only ones for 200 million years, until pterosaurs emerged. Wings gave them an enormous boost, helping them find food and mates, colonise new habitats, avoid predators and regulate their body temperature. Winged insects thrived. An astonishing menagerie filled the skies of the late Carboniferous and Permian periods between 323 and 252 million years ago. As tiny plants evolved into massive trees, coal-swamp rainforests spread across equatorial regions. Here, lacy winged palaeodictyopterans sucked the sap from plant stems through elongated beaks and gigantic griffinflies hawked their prey (see "There be giants", left). There were also more familiar flyers such as mayflies and dragonflies, but all had wings projecting

outwards from their bodies, even at rest, making them vulnerable to damage and limiting the habitats they could colonise.

These "old-winged" insects were about to be upstaged, however. Down in the litter on the forest floor were "new winged" insects with hinge mechanisms to fold their wings over their bodies when not in use. This innovation meant they could use hiding places and habitats not available to their forebears. Foremost among them were the ancestral roaches, as successful then as they are today.

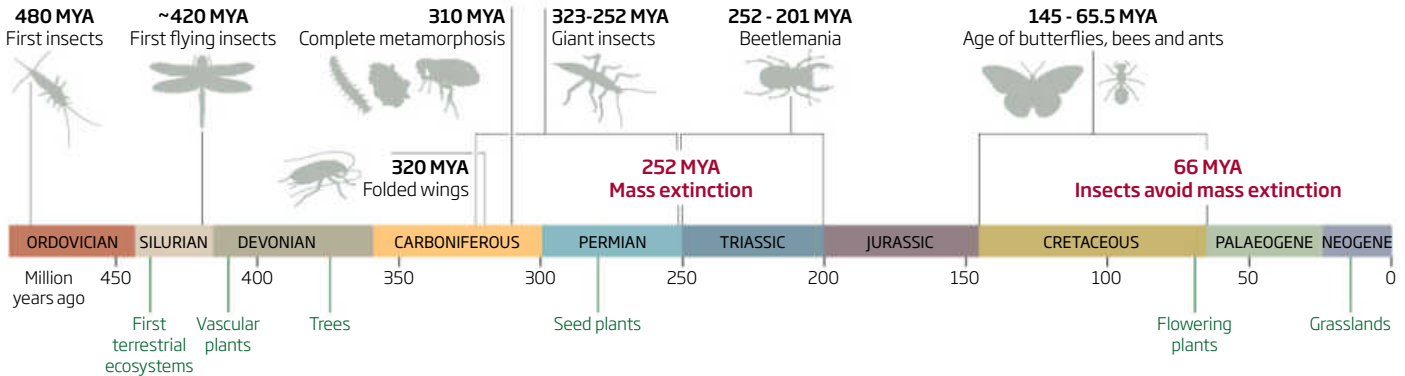
Yet the insects were to undergo a further transformation – arguably the most important innovation of all, and its evolution was only pinpointed a couple of years ago. Dazzled by the spectacular creepy crawlies in coal swamps, researchers missed something else going on. "There are dark, coal-rich rocks from 310 million years ago with insects that were only spotted under the microscope," says André Nel of the National Museum of Natural History in Paris. Their small size belies their significance. These are the oldest known insects to undergo complete metamorphosis.

Insects are fundamentally constrained by their inflexible exoskeleton. Until this point, they had grown via a series of nymphal

"Metamorphosis was such a successful innovation that more than eight in 10 insect species use it today"

Rulers of the Earth

Ancient origins, ingenious innovations and admirable adaptability mean that insects comprise three-quarters of all known living animals



stages, each followed by a moult, allowing miniature forms resembling the adult to get progressively bigger. Complete metamorphosis, by contrast, enabled the insects to divide their life cycle into distinct stages, with the larva specialised for feeding and the adult dedicated to reproducing. The larva, pupa and adult stages of completely metamorphosing insects are thought to be the evolved equivalent of the pronymph, nymph and adult in ancestral insects. This development has proved so successful that more than eight in 10 insect species use it today. Back then, though, Nel's tiny insect fossils, which later evolved into beetles, fleas, wasps, bees and ants, were rarities. "Maybe the ecological niches were occupied by other groups and only after they became vacant could they diversify," he says. This was about to happen.

The most catastrophic mass extinction the world has ever seen came 252 million years ago. Over many millions of years, immense volcanic eruptions, global warming and falling oxygen levels wreaked havoc on Earth's life-support systems, killing off up to 90 per cent of all species on land and in the oceans. This time, unlike earlier mass extinctions, even insects were affected. "There was an enormous shift at the end of the Permian with about 50 out of 110 insect families going extinct," says Peter Mayhew at the University of York, UK, whose team scoured the fossil record to work this out. Gone were the giant griffinflies, the palaeodictyopterans and many other "old wings". But Mayhew's team found one notable exception. This extinction was the making of metamorphosing insects. "They were generating new families and were hardly touched," he says.

How did they succeed where others failed? For a start, they are often smaller, develop more rapidly and have larger populations than other types of insect, all of which allow them to recover quickly following a crisis. But they also had an ace to play. The pupa – the

BANE OR BOON?

There are many reasons to dislike insects. They spread some of the world's deadliest diseases including malaria and typhoid. Some destroy crops. Others bore into wood. Stinging insects and parasites can make life a misery. But just one insect in a thousand is a pest – most are harmless and many beneficial.

Insects pollinate four-fifths of the world's crops, amounting to one-third of food production, not to mention our garden plants. We eat their honey, wear their silk and use their dyes and waxes. Where would we be without their pest control, soil fertilisation and ability to clean up by scavenging corpses and waste? They are packed with protein, which could one day feed the world. Fruit flies do sterling work in the lab and together with other insects have been instrumental in medical breakthroughs. And the rate at which some creepy crawlies decompose bodies can even help solve crimes.



transitional phase between larva and adult – evolved a way to store very high levels of glycerol, helping it withstand freezing and desiccation, so making it very hardy during times of environmental stress.

A recognisably more modern insect fauna ushered in the Triassic. This period, 252 to 201 million years ago, was boom time for beetles. Not only were they small, fecund and able to metamorphose, their forewings had hardened to protect their folded hindwings and conserve moisture and warmth. They were able to colonise a huge range of habitats, from deserts to ponds, and from the Arctic to the tropics. So successful were they that today there are at least 400,000 known beetle species, more than any other type of insect.

For insects, everything was coming up roses. The Cretaceous saw another enormous explosion in insect diversity, with the appearance of flowering plants. This time it was the turn of butterflies, moths, flies, bees and ants. "Flowering plants provided a rich new landscape of resources," says Engel. Like their ancestors before them, these insects took full advantage of the opportunities on offer. "You are getting continued bumps in diversity as each period there are new additions to insects' cocktail of innovations, helping certain groups speciate wildly," he says. When an asteroid impact put an end to the dinosaurs, 66 million years ago, insects breezed through and continued to go from strength to strength.

"There's a long fuse," says Engel. "Insects took this super powerful concoction of traits that built up over hundreds of millions of years, and conquered the world." They have succeeded by longevity, innovation, adaptability and evolutionary exuberance. In today's world they face another challenge, but their diversity and talent for survival will stand them in good stead. As other animals struggle to cope with global climate change, it looks like insects will continue to rule. ■

James O'Donoghue is a writer based in Norwich, UK

Uploading depression

Can mental healthcare delivered over the internet replace human therapists?
Samantha Murphy investigates

MEAGHAN FRITZ used to break out in cold sweats before meetings. A simple discussion with her boss would leave this otherwise confident woman stuttering and dizzy. To meet her, you'd never imagine she suffered from severe social anxiety. Then again, it surprised her too. Fritz had been treated for depression for years. "I've tried Seroquel, Lexapro and Xanax," she says, rattling off a list like someone who has tried it all. But nothing quite worked. In fact, according to Fritz, she wasn't even looking for help any more. "I knew I had a problem, but I didn't know what it was," she says. "It wasn't until I took the test at Joyable that I had a name for it."

Joyable is a start-up that offers counselling over the internet. It not only finally gave Fritz her diagnosis but, \$100 and 12 online sessions later, she was seeing improvements in her private and professional life too – all without meeting a therapist. Joyable is part of a new generation of computer-based therapies that some think could greatly reduce the burden on mental healthcare providers – and perhaps do away with face-to-face sessions altogether.

"There's a genuine need for something that can be used to meet the unmet needs of people with depression," says Simon Gilbody at the University of York, UK, who studies mental health services. "There's still overprescription of antidepressants and woefully inadequate provision of psychotherapies." As resource-strapped organisations like the UK's National Health Service struggle to meet the demand for treatment, online tech is taking up the slack. The NHS currently approves seven mental health apps. Its Health Apps Library – a pilot project that ran from March 2013 until this summer, now being revised – approved 26. And there are hundreds more, like Joyable,

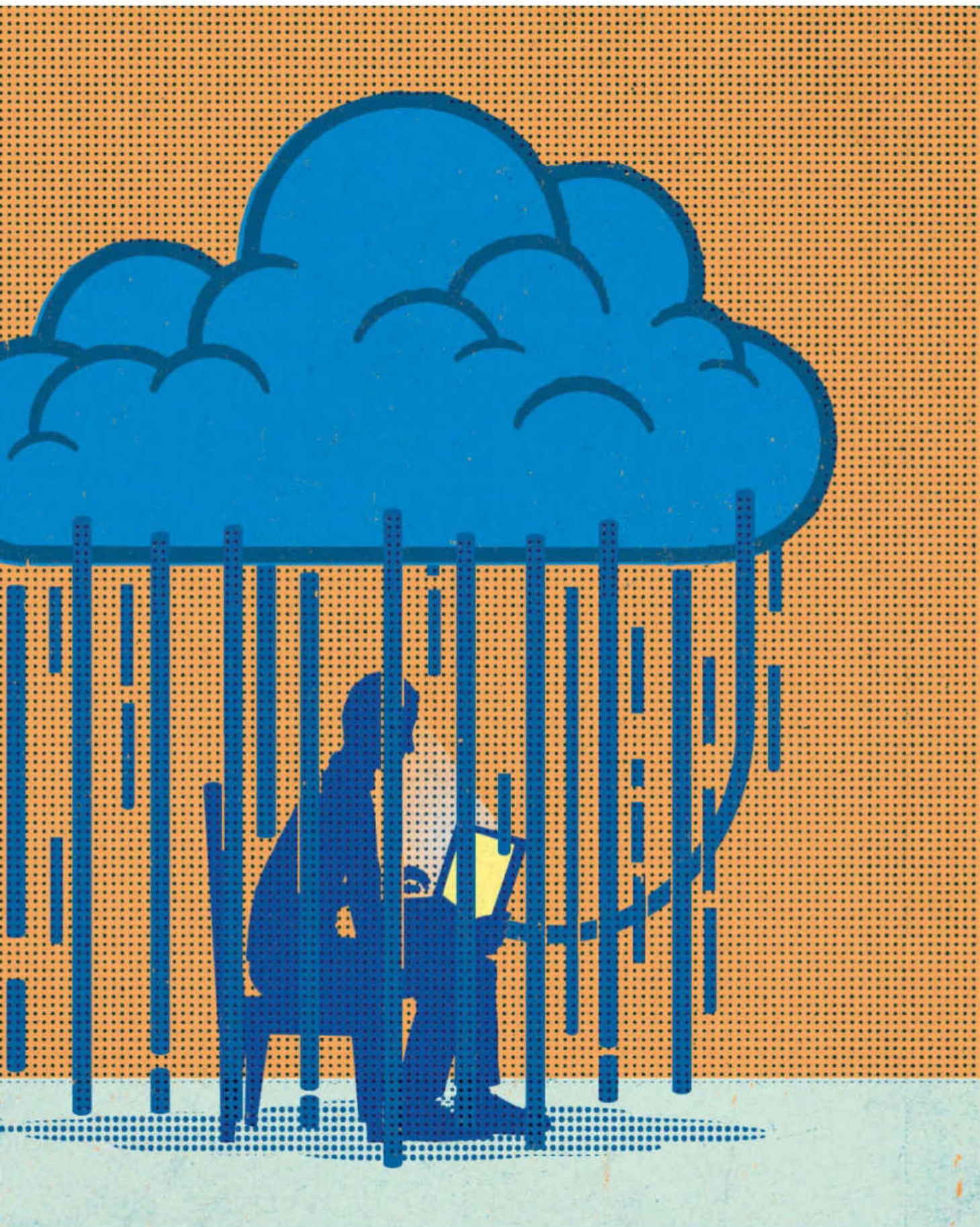
without official backing. Some offer do-it-yourself counselling, some put people in touch with healthcare professionals remotely, and some are built on peer support.

There is little doubt that computer-based treatments will play a big part in the future of mental healthcare. The UK government recently launched a £650,000 innovation prize to encourage the development of the next generation of tech. But is it the solution or are we offloading care by uploading it?

Cognitive behavioural therapy (CBT) is one of the most widespread treatments for mental health conditions such as anxiety and depression. By talking with a therapist, patients are helped to change the way they think and behave. The idea behind computer-based CBT (CCBT) is to achieve similar results by delivering the change-inducing message on screen rather than in person.

"CBT relies much more on educating people than on the relationship that develops between a person and the therapist," says psychiatric epidemiologist Glyn Lewis at University College London. "So the main online applications have tried to capture that educational element."

There are clear advantages. For a start, computer-based services are available immediately. In the UK, half of those who need mental healthcare have to wait three months for any other kind of treatment; 1 in 10 have to wait over a year. Even for patients receiving therapy, a computer program is arguably far more convenient. In practice, psychotherapy can be a hassle, says Lewis. "You've got to turn up somewhere every week, you often have to miss work." And then there are those who would prefer not to seek help from a therapist at all because of the stigma still attached to mental health problems. Computer-based ➤



THE THERAPIST IN THE ROOM

alternatives allow more flexibility in how CBT is delivered.

The trouble is, they might not work. True, a handful of recent studies concluded that CCBT often gave results as good as – and sometimes better than – face-to-face therapy. There was enough evidence for the UK National Institute for Health and Care Excellence (NICE) to tentatively recommend the use of online apps in its current guidelines, says Gilbody.

But Gilbody and colleagues are about to publish results that overturn those findings. In the largest trial so far, the team recruited 690 patients who were being treated for depression across the UK. It looked at whether either of two CCBT packages – Beating the Blues, a market leader developed by London-based company Ultrasys and approved by the NHS, and a free online package from the Black Dog Institute in New South Wales – provided any additional benefit compared with standard treatment and antidepressants alone. Patients were randomly allocated one of the three options. The researchers checked their progress after 4, 12 and 24 months, which included measuring levels of depression, assessing quality of life, and whether they were back at work.

Throwing money

The results were far less impressive than reported in previous research. Giving people a piece of software and a few supportive phone calls isn't enough to treat a complex condition like depression, says Gilbody. "People really didn't engage in the technology in the way we'd expected them to."

Why the conflicting results? Most other trials have been quite small and some were conducted by people behind the apps being tested, says Gilbody. "There was very little out there in the way of independent evaluation."

Gilbody concedes that CCBT might provide a stopgap, particularly where there are long waiting lists for face-to-face talking therapies. But he thinks the benefits are slight. The trial also found no difference between the paid-for and free courses. "We think the NHS should stop throwing money at commercially provided products," he says.

Arguably, the pitfalls of CCBT are somewhat predictable. "It's like working from home," says Hillary Rothrock, who used to be a mental-health crisis worker and has herself tried online counselling. "You get out what you put in." But for many with depression, motivation is a problem. The more support you give people the better they engage with CBT, says Lewis. He thinks the level of support people need to get a clinical benefit from these systems is not yet

"I think when you have a therapist, you have an extra personality in the room," says Hillary Rothrock, a former mental-health worker based in Maryland. "It influences the therapeutic dynamic." Rothrock and her husband turned to online counselling a few years ago to save their marriage. "Doing it this way kept it between him and me," she says. "We weren't trying to influence anyone else's opinions."

If three's a crowd, two is not necessarily company. A 2014 study by Gale Lucas at the University of Southern California in Playa Vista and colleagues showed that, even in a one-on-one situation, people were more willing to disclose details about their mental well-being to an on-screen avatar if they believed it was controlled by a computer rather than a human. The researchers behind the study suggest that automated "virtual humans" might help therapists gather accurate information from their patients.

Communicating via keyboard can itself have advantages over face-to-face speech, says Glyn Lewis at University College London. "When you talk to people there tends to be a lot of chit-chat," he says. "By getting people to write things down, you're getting straight to the point. That may speed up the therapy process."

clear. "If I'm learning French I could go out and buy a CD or I could go to a class," he says. "The danger with just buying the CD is you can leave it unopened for several months." Gilbody thinks it's a good analogy. "I play better guitar than I speak French because I have a guitar teacher turning up every Friday," he says.

For Fritz, frequent interactions with a Joyable counsellor were key to her positive experience. He gave her things to read and tasks to do. He was quick to respond to emails when she needed him. "I've done CBT before and this was so much better," she says. Of course, this is anecdotal. But Gilbody's trial also highlighted the need for interaction – whether for guidance or encouragement. "The thing most participants reported missing was the human contact," he says.

Other people were also what Jamie Druitt missed when he suffered from depression after the break-up of his marriage. It's what led him to set up TalkLife, a social network that

caters specifically for people with depression, anxiety disorders and self-harming behaviour. "Your mates are just like, let's go out for a beer, you'll be fine," says Druitt, looking back. It wasn't enough, he felt. "I firmly believed that there were people around the world going through exactly the same thing."

Of course, he was right. He launched the app in 2014 and within a matter of months it became a place where tens of thousands of people – especially teenagers – were sharing experiences and offering each other support. TalkLife now has 180,000 users from 120 countries. "Kids in Botswana are helping kids in the US," he says. Druitt's idea was to take the best bits of social networks like Facebook – the connections, the sharing – and build a safe haven around them. "You can't put a post up on Facebook or LinkedIn about how you're actually feeling," he says. Among the usual online banter, people discuss self-harm, running away, abuse.

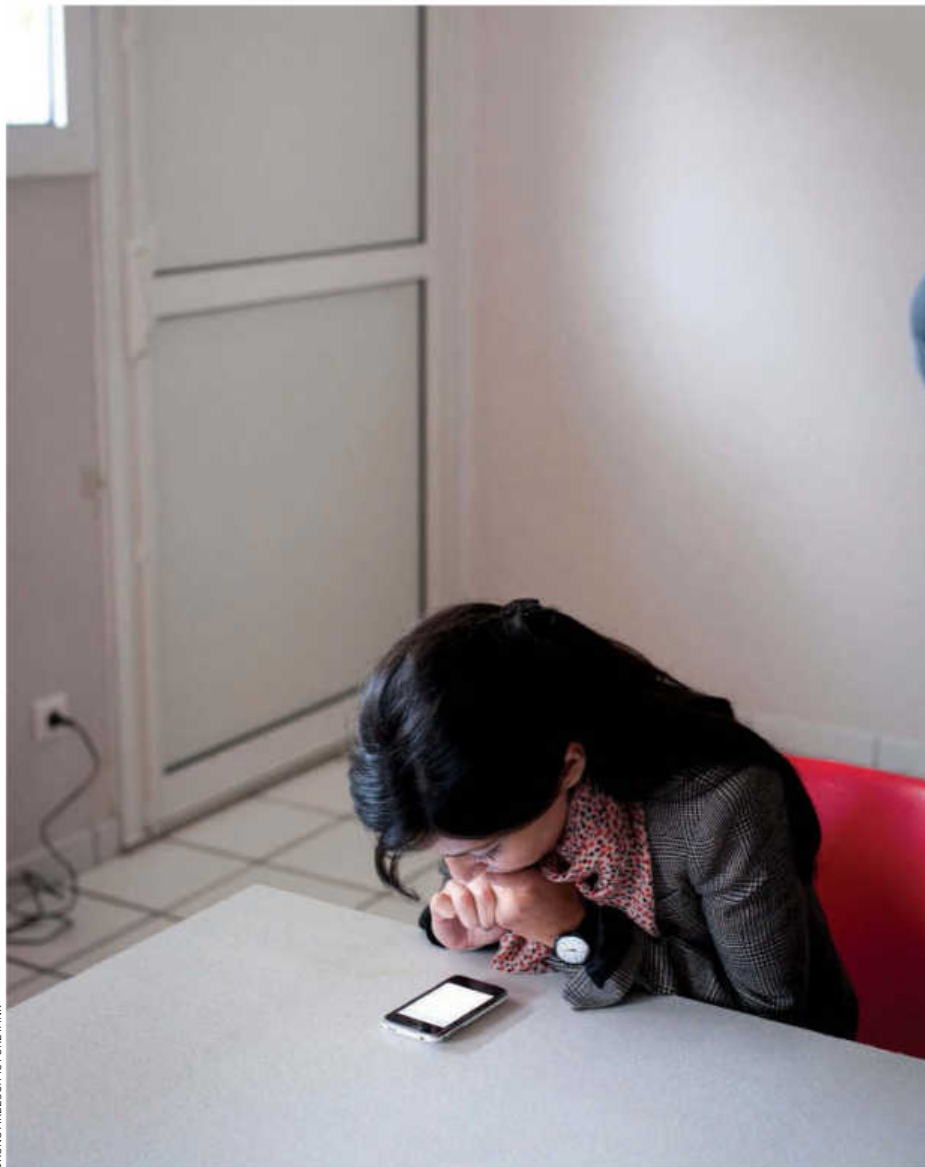
Druitt wants TalkLife to be the online therapy that works. Too many people struggle with depression or anxiety without seeking help, he says. He is convinced some just need a place to open up. "We see people come in in a crisis state and then within about 30 days turn around to become amazing helpers, sharing their story with others," he says.

But what sets TalkLife apart is the work going on behind the scenes. Druitt realised that the millions of posts being produced were an invaluable source of data. So he contacted people he thought could do something with it.

"We noticed immediately that people talk about things on TalkLife they would not talk about in person," says computer scientist Karthik Dinakar at the Massachusetts Institute of Technology, one of around 20 researchers now working on TalkLife. "We've never had data of this kind on this scale before." The team also includes Matthew Nock at Harvard University, who is a leading researcher on self-harming behaviour, and researchers at Microsoft Research in Redmond, Washington.

"TalkLife aims to understand users' mental well-being and intervene if necessary"

As with Facebook and Twitter, Dinakar and his colleagues are using machine learning algorithms to analyse what he calls breadcrumb trails – tracking what users say, who they say it to, what they read, what they like, and so on. "All these behavioural breadcrumbs are used heavily for monetisation on virtually every social network," says Dinakar. "Most people in



BRUNO ARBESU/PICTURETANK

machine learning are doing all they can to make people click on ads.” But with TalkLife, the aim is to understand users’ mental well-being – and intervene if they need help.

To do this, the researchers have built computer models based on Nock’s detailed characterisation of self-harming behaviours. By applying these to TalkLife data, the team can study such behaviour as it plays out in real life. “Why people engage in self-harm is far more complex and nuanced than clinical models often capture,” says Dinakar. “And they do it in spurts, not all the time.”

Scott Counts at Microsoft Research has previously had success applying a similar technique to postnatal depression. It’s a very under-reported condition, says Counts. “A lot of women don’t even realise they have it. You’re tired, but of course you’re tired, you just had a baby.” By looking at women’s Facebook and Twitter activity before and after giving birth, Counts found he could identify

Sharing and caring: people talk about things online they would not talk about in person

those who suffered some form of depression. Indicators included the number of friends or followers an individual had, whether she asked a lot of questions, and even the words she used. Increased use of the first-person pronoun, which tends to reflect an increased inward focus on the self, is correlated with depression, for example. Counts also looked at whether anyone was talking back. “You could be posting like crazy,” he says. “But are you actually interacting with people?”

He then realised some indicators, such as apparent stress levels, allowed him to make a prediction even before a woman had her baby. “The next step – and this is similar to what’s happening with TalkLife – is to start putting these results into practice,” he says. With postnatal depression, for example, Counts imagines pregnant women using an app that

relays information of this kind to their doctor.

A big advantage of using online breadcrumb trails rather than the standard questionnaire to assess mental health is that breadcrumbs don’t lie. “They’re generated in the flow of life and therefore reflect everyday experience,” says Counts. “Pronoun usage, for example, is very hard to fake.” When you ask someone to fill in a questionnaire, they have time to think.

With its growing community of active users, TalkLife now has ample data with which to make its own predictions. Go to a doctor with a cold and she might tell you to take paracetamol and come back if you’re not feeling better, says Dinakar. If you are still ill,

“Social interactions online can be used to predict depression automatically”

she will try something else. “We would like to do something like that with TalkLife,” he says. Druitt hopes to start rolling out automatic interventions next year. Details have yet to be announced, but potential actions include automatically connecting people in trouble with someone who has been through similar experiences and presenting people with CBT-inspired messages designed to help them change their thinking. “You can think of them as our ads,” says Dinakar.

For many, the thought of a personal psych profile sitting on a social network’s servers will ring alarm bells. The NHS has already been criticised for recommending apps with dodgy data handling practices, for example. The risks of sensitive data being leaked or misused are real. But Druitt says the TalkLife team are open with their users about what they are doing and that the new features will be opt-in only. He thinks the community will be supportive.

In time, such systems could be added to other social networks. Dinakar has been invited to talk at Facebook. And Thomas Insel recently left the US National Institute of Mental Health to head Google Life Sciences (see page 27). Like the TalkLife team, he thinks machine learning can help us study mental health. It might also improve CCBT.

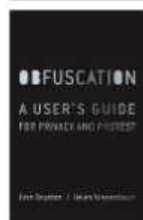
Ultimately, Counts thinks we might all end up with mental well-being monitors in our pockets. They would track our social lives, crunch psychological metrics and give us regular updates. Fitness trackers are now common, why not mental fitness? “It’s not that different from monitoring your pulse or your glucose level,” he says. ■

Samantha Murphy is a writer based in Pennsylvania
Additional reporting by Douglas Heaven

Pretty bad privacy

Protecting our data is a very complex affair, finds **Sally Adee**

Obfuscation: A user's guide for privacy and protest by Finn Brunton and Helen Nissenbaum, MIT Press, \$19.95/£13.95



SECURITY theatre has reached new heights of absurdity: we perform this meaningless ritual whenever we change our

passwords to digits only a quantum computer could love, repeating the process every three months separately for each of the hundreds of sites and apps we use.

As if this busywork could give us any control over our data! A password has little to do with security any more. It can't stop the NSA from tapping in to the secret back doors left by mobile or email providers. Nor can it keep Facebook's ever-shifting, intentionally confusing privacy policies from ensuring that advertisers will use your data for their own opaque purposes.

Small wonder a recent poll by the Pew Research Center found that while we worry, we do little to protect our personal data. For example, we don't flock to Tor privacy software to cover our tracks – though, ironically, doing so would raise red flags at the NSA, prompting closer monitoring.

If thinking about this makes you tired, Helen Nissenbaum has a phrase for you: “security fatigue”. Nissenbaum and Finn Brunton are information researchers at New York University, and they wrote *Obfuscation* to start a revolution.

Exasperated by the widening chasm between security theatre and reality, they wondered if there



FRÉDÉRIC LECLOUX / AGENCE VU / CAMERA PRESS

was another way to resist the industrial spying/marketing/data-siphoning complex, one that didn't require major policy or technology overhauls. The resulting book bills itself as “a user's guide for privacy and protest”, and as an encyclopedia of the various ways people have covered their tracks, it's both intriguing and instructive. But if you were looking for something “for dummies”, it falls somewhat short as many of its best exemplars are has-beens or never-weres.

Take FaceCloak. Announced in 2009, it promised the impossible:

“Future generations may laugh that we took so long to see the best obfuscation is cold, hard cash”

Web of thieves: individual security efforts online are next to useless

use Facebook, but keep your data out of the coffers of the company and its business partners. The idea was simple: “upload” a photo to Facebook, and FaceCloak would store place-holding ciphers in Facebook's database, while it redirected the real information to a separate, encrypted server. This let you use the shell of Facebook without surrendering your data.

The FaceCloak site is now a mausoleum to ambitious privacy projects that fail in the face of mundane realities (for it to work, you would need to convince all your friends to use it too). It's also a reminder that it's hard to make money out of unsupported apps,

especially those that don't trade your data. In 2012, FaceCloak quietly stopped updating its code.

The book raises other intriguing questions about obfuscation. For example, is it always ethical? Take TrackMeNot, a plug-in that masks Google search queries by burying them in a vast cloud of fake requests. Here's the dilemma. In 2011, Greenpeace estimated that if the internet was a country, it would rank sixth globally in electricity demands. In 2015, a search for “David Cameron pig gate” uses 0.3 watts of electricity, 0.2 grams of CO₂ and a few drops of cooling water. Send 100 obfuscators to hide the search, and these costs balloon. It's a new tragedy of the commons: a few people can coast on the rest of the herd, but what if we all use it?

Fascinating stuff, but the book can feel like a bit of a jumble as it skips along. This is a shame because while *Obfuscation* may fail as a “for dummies” guide, for anyone who wants to grasp the layered complexities of keeping their data safe, it is required reading. Particularly for those of you building the next generation of obfuscation apps, the book's back-page decision tree will help you avoid the fate of FaceCloak.

Perhaps unwittingly, the book demonstrates the futility of individual resistance against state/corporate algorithms. Let's face facts: either we let apps suck up our data or we pay hundreds a month for our games, music, social networks, email and so on.

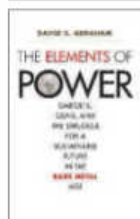
Future generations may laugh that we took so long to see the obvious: the best obfuscation is cold, hard cash. If the authors have revolution in mind, it'll have to be of a very different kind. ■

Elements of a quandary

Can mining rare metals really save the world, asks **Jonathon Keats**

The Elements of Power: Gadgets, guns, and the struggle for a sustainable future in the rare metal age

by David S. Abraham, Yale University Press, \$30



IN THE hills of China's Jiangxi province, men spend their days digging pits and pouring acid over the dirt. This separates rare

earth elements, including dysprosium and terbium, from the clay. The minerals are purified in bright blue treatment pools, baked in a kiln and sent to market. It's a wasteful business: 99.8 per cent of the clay being mined contains nothing useful and is simply dumped back on to hills and into water. It's also toxic, poisoning wells, killing crops and stripping nearby streams of life.

The quest for rare metals, small quantities of which are vital for modern technologies, has caused severe environmental damage everywhere from Chile to the Democratic Republic of the Congo. Yet, according to David S. Abraham, our future depends on pulling these metals from the Earth. "Mining is not antithetical to a green economy," he writes. "It's a necessity."

Abraham describes how we handle these elements, from prospecting and trading to manufacturing and recycling. He also discusses their current and future applications, ranging from smartphones to fighter jets, showing how much more of the periodic table we exploit with

each passing decade. (In the 1990s, Intel's microchips depended on 15 elements; they now require nearly 60.)

This reliance would seem grotesque if there was a simple trade-off between products on one hand and environmental ruin on the other. What complicates things is the role rare metals play in renewable energy.

The dysprosium mined in Jiangxi is an essential ingredient of high-strength magnets, around 150 kilograms of which are installed in each 3-megawatt wind turbine. Dysprosium-doped magnets are also crucial in electric cars. That places extraordinary pressures on Jiangxi's mines, which are chief among very few sources of the stuff worldwide. A Massachusetts Institute of Technology study cited by Abraham predicts that dysprosium extraction will have to rise by 2600 per cent in the next 25 years to produce enough turbines and electric vehicles to

have an impact on global warming.

Other essential elements of the green economy, according to Abraham, range from lithium to titanium, tellurium to niobium. Niobium is used to strengthen steel, making for lighter, more fuel-efficient vehicles. Those structural advantages can also decrease steel production as a whole – no small thing when you consider that steel-making is the world's most carbon-intensive

"Dysprosium is an essential ingredient of the high-strength magnets used in wind turbines"

industry, emitting 2.5 gigatonnes of carbon dioxide annually.

These and other examples lead Abraham to stake our future on the miraculous qualities of rare metals. By his reckoning, their advantages far exceed the harm of mining. "It's better to process rare metals once... than to keep on extracting and burning new coal,"

he reasons. He also contends that metallurgy research can improve extraction techniques, and that tighter regulation can reduce the damage mining causes.

Abraham's logic is compelling, even if his belief in the global reach of beneficent policy-making seems a tad naive. His passion for rare metals is genuine, and can be inspiring. But he takes it for granted that consumer demand for goods and energy must be appeased and – aside from one halting paragraph on conservation in his last chapter – that technological innovation can mitigate environmental ruin.

Abraham is certainly correct that rare metals can prolong economic growth. What remains to be seen – and ought to be questioned – is whether advances in renewables can outpace the damaging impact of our lust for rare metal-enabled gadgets. ■

Jonathon Keats is a conceptual artist and experimental philosopher



Rare earth extraction may in the long run help arrest global warming

Mendeleev's revenge

A new show with chemistry at its heart has no choice but to fail gloriously

Periodic Tales: The Art of the Elements, Compton Verney, Warwickshire, UK, to 13 December

Simon Ings

THE haunting, slightly bilious yellow-green of uranium glass fascinated Victorian interior designers. Uranium metal glows green in ultraviolet light, and this property lends uranium glass a subtle yet compelling inner fire.

The Victorians made any number of knick-knacks out of the stuff. The *Periodic Tales* exhibition at Compton Verney – a stately home near Stratford-upon-Avon, UK, best known for its collection of British folk art – boasts a piano foot, an ornamental castor fashioned to spread the weight of a parlour piano.

It is mildly radioactive, which triggers all manner of safety protocols. “We installed it using special gloves,” says Penelope Sexton, the exhibition’s curator. “I shudder to think what any passing Victorian would have made of us.” Sexton is leading Compton Verney’s long-term campaign to become a contemporary arts venue and attract day visitors from all over the UK.

Periodic Tales combines simple objects made from different elements – a tiny lead figurine from the Aegean islands is the oldest, dating from around 2500 BC – with art that draws contemporary mischief from Dmitri Mendeleev’s world-changing periodic table of the elements.

Before modern chemistry, it was assumed that the properties of fundamental materials were

innate and could be combined. By that logic, blending sulphur’s yellow and mercury’s sheen ought to have made gold. Mendeleev, a Russian chemist and inventor, spoiled that dream in 1869 by codifying the elements we recognise today in a table that reflects a profound atomic reality we know to be true but cannot directly see.

To read the periodic table is to be confronted by how baffling the world is. Solids, liquids and gases nestle against each other for reasons that cannot be unpicked by simply resorting to an intuitive understanding of the human-scale world. The queer thing about calling this show *Periodic Tales* is that there are no tales to tell, only a stunned acknowledgement that one can, in the same moment, both be handed the keys to the material world, and firmly locked out of ever intuiting it.

The artworks Sexton has chosen

struggle for purchase. Simon Patterson’s periodic tables of celebrity are facile. And Cornelia Parker’s circle of crushed silver ornaments is almost as pretty as a well-lit silver object would have been had she not crushed it in the first place. Maria Lalic’s chrome mirrors are pure Ikea.

But there are some stunning successes, too. The frames of John

“The periodic table is a masterpiece of objectivity. Its truth refuses to be anthropomorphised”

Newling’s wall-mounted *Value; Coin, Note and Eclipse* capture the alchemical transformation of a living plant into gold coinage, by way of pressed kale leaves and the judicious application of gold leaf. It is a narrative piece, rooted in the safe ground of material production, value and exchange.

It is significant, I think, that

other standout pieces also explore the way some elements are more or less effortlessly turned into cultural signs – quite literally in the case of Fiona Banner’s neon *Brackets (An Aside)*.

There is much else in the show worth seeing: Danny Lane’s *Blue Moon* makes cobalt positively drinkable. And there’s plenty to think about with another work by Parker, *Stolen Thunder*, which is a display of handkerchiefs stained by the tarnish rubbed off famous objects.

But, counter-intuitively, the real draw is the necessary failure of the show. Sexton has brought us right to the edge of what art can do to communicate science, and then some. But Mendeleev’s table is a masterpiece of objectivity. Its truth refuses to be anthropomorphised, moralised upon or otherwise domesticated. *Periodic Tales* was bound to fail, and does so, splendidly. ■



Periodic thinking: John Newling's *Value; Coin, Note and Eclipse*



FGCU invites highly qualified applicants to apply to the following positions:

College of Arts & Sciences

Chemistry, Instructor I, Req. #2410 (2 Positions)

Biology, Instructor I, Req. #2413 (2 Positions)

Environmental Studies, Assistant Professor, Req. #2416

Physics, Instructor I, Req. #2419

Environmental Studies, Instructor I, Req. #2421

To apply, please visit our website at <http://jobs.fgcu.edu>
and access the Req. # for detailed information and deadline dates.

Application materials will only be accepted online.

FGCU is an EOE, AA M/F/Vet/Disability Employer.



Research Assistant Professor

Applications are invited for a Research Assistant Professor position in the Institute for Quantum Computing (IQC) and any department in the Faculties of Mathematics, Engineering and Science. The IQC is a collaborative research institute focused on quantum information, science and technology. Membership in IQC is a five-year appointment, subject to re-evaluation after three years taking into consideration performance and availability of funding. Only those candidates whose research program directly connects with the goals and ongoing research at IQC will be considered. Information about research at IQC can be found at <http://uwaterloo.ca/iqc/research>.

A PhD and significant evidence of excellence in research in quantum information science and technology are required. Based on qualifications a salary range of \$70,000 to \$90,000 will be considered. Negotiations beyond this salary range will be considered for exceptionally qualified candidates. Effective date of appointment is negotiable.

The University of Waterloo is host to the Institute for Quantum Computing. At present, IQC has a complement of 22 faculty members (growing to 33) from the Faculties of Engineering, Mathematics and Science. Interested individuals should upload their application via the faculty application form at: <http://uwaterloo.ca/iqc/positions>.

The application review process will begin on **Dec 1st** and continue until the position is filled.



Faculty Position

Applications are invited for 1 or more tenure-track faculty positions, at the rank of Assistant Professor in the Institute for Quantum Computing (IQC) and any department in the Faculties of Mathematics and Science. The IQC is a collaborative research institute focused on realizing quantum technologies including sensors, actuators, quantum communication, and information processors. Membership in IQC is renewable, with an initial appointment of 5 years, and comes with research space, a teaching reduction of one course and a stipend. Only those candidates whose research program directly connects with the goals and ongoing research in IQC will be considered. Information about research at IQC can be found at <http://uwaterloo.ca/iqc/research>.

A PhD and significant evidence of excellence in research in quantum information science and technology and the potential for effective teaching are required. Responsibilities include the supervision of graduate students, as well as teaching at the undergraduate and graduate levels. Based on qualifications, salary range of \$75,000 to \$155,000 will be considered. Negotiations beyond this salary range will be considered for exceptionally qualified candidates. Effective date of appointment is negotiable. The search is open to all areas of quantum information. The search committee will consider all creative and energetic candidates in any area of research focused on advancing quantum information.

The University of Waterloo is host to the Institute for Quantum Computing. At present, IQC has a complement of 22 faculty members (growing to 33) from the Faculties of Engineering, Mathematics and Science. Interested individuals should upload their application via the faculty application form at: <http://uwaterloo.ca/iqc/positions>.

The application review process will begin on **December 1, 2015** and continue until **March 31, 2016**.

The University of Waterloo respects, appreciates and encourages diversity. We welcome applications from all qualified individuals including women, members of visible minorities, Aboriginal peoples and persons with disabilities. All qualified candidates are encouraged to apply; however, Canadian citizens and permanent residents will be given priority.

Three reasons to apply: <https://uwaterloo.ca/watport/why-waterloo>.



Assistant/Associate Professor Physics Education Research Kansas State University

The Department of Physics at Kansas State University seeks a faculty member to join its physics education research (PER) group. Experience with research on the teaching and learning of physics that complement and/or expands the existing PER efforts at KSU will be considered favorably. The successful candidate will be appointed at a rank of tenure-track Assistant or Associate Professor in the Physics Department. Candidates must present credentials which will justify appointment at one of these levels. Minimum requirements include a Ph.D. in physics education research or equivalent and research experience beyond the doctorate.

The Department has an outstanding physics education research program (KSUPER), which was founded in 1972. At present KSUPER includes two faculty members. A detailed description of research activities, post-docs and graduate students in KSUPER can be found at <http://www.phys.ksu.edu/ksuper>. For further information contact Eleanor Sayre (esayre@phys.ksu.edu) or Dean Zollman (dzollman@phys.ksu.edu).

The successful candidate will also demonstrate a strong commitment to teaching and mentoring of students and to serving a diverse population. He/she will be expected to obtain external funding for research activities, collaborate with other faculty in physics and other academic departments and build a national and international reputation in PER.

Applications should be sent, to PER Search Committee, 116 Cardwell Hall, Kansas State University, Manhattan, KS 66506-2601 or to persearch@phys.ksu.edu. Applications should include a cover letter that addresses qualifications for the position, a curriculum vita, and statements of research and teaching interests. The applicant should arrange to have three letters of reference sent to the address above.

Screening of applicants will begin on December 1, 2015, and continue until the position is filled.

Kansas State University is an Equal Opportunity Employer of individuals with disabilities and protected veterans and actively seeks diversity among its employees. Background checks required.



D. E. Shaw Research is a New York-based independent research laboratory that conducts basic scientific research in the field of computational biochemistry under the direct scientific leadership of Dr. David E. Shaw. Our lab has designed and developed multiple generations of a massively parallel supercomputer called Anton specifically for the execution of long-timescale molecular dynamics simulations. Our group is currently focusing on molecular simulations involving proteins and other biological macromolecules of potential interest from both a scientific and a pharmaceutical perspective. This is an ambitious, long-term project aimed at fundamentally transforming the process of drug discovery.

Members of the lab include computational chemists and biologists, computer scientists and applied mathematicians, and computer architects and engineers, all working collaboratively within a tightly coupled interdisciplinary research environment. For internships and full-time positions, we welcome applicants of all levels of experience from a broad range of backgrounds, including electrical and computer engineering, computer science, applied mathematics, chemistry, biology, physics, materials science, and related fields.

D. E. Shaw Research is committed to building a diverse team. Our aim is to recruit remarkable people who have the potential to make significant long-term contributions to our efforts. We offer an intellectually rigorous and stimulating work environment that is also supportive, flexible, and welcoming. We pride ourselves on the caliber of our team, and we offer above-market compensation.

To learn more about our research and current opportunities at the lab, we invite you to visit our website, www.DEShawResearch.com.

D. E. Shaw Research does not discriminate in employment matters on the basis of race, color, religion, gender, pregnancy, national origin, age, military service eligibility, veteran status, sexual orientation, marital status, disability, or any other protected class.

D E Shaw Research

**KANSAS STATE
UNIVERSITY**



ASSISTANT/ASSOCIATE PROFESSOR SOFT MATTER EXPERIMENT CONDENSED MATTER GROUP DEPARTMENT OF PHYSICS

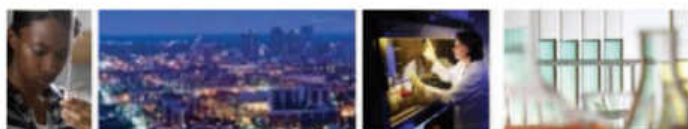
The Department of Physics at Kansas State University seeks an experimental physicist with research interests in soft condensed matter physics. Areas of interest include nanoparticle assembly, biological problems at the cellular and molecular levels, emergent phenomena, macromolecules, structured fluids, colloids and aerosols, and light scattering and its application to these systems. Such a scientist might engage in experimental research at the molecular or continuum levels of these physical or biological systems. Cross disciplinary research plans that overlap with ongoing AMO projects in the department (strong field laser-matter interactions, plasmonics, ultrafast charge transport) will be reviewed with interest, but are not required. The successful candidate will be appointed at the rank of tenure-track Assistant or Associate Professor in the Physics Department. Candidates must have a PhD in physics or a closely related field. To be considered for the Associate level position candidates must present credentials which will justify appointment at that level. The successful candidate should also demonstrate a strong commitment to teaching and mentoring of students and to serving a diverse population.

The Department has outstanding experimental and theoretical Condensed Matter physics programs involving seven faculty members most of whom are involved in research related to soft matter physics. Faculty research interests include synthesis and self-assembly of nanoparticles, surface structure and surface interactions of nano/bio components, light scattering, metallic and conducting polymer nanowire fabrication and applications, cellular adhesion and migration, aggregation phenomena for both proteins and particles, and nanostructured magnetic systems. The soft matter group has strong ties and collaborations with faculty in Chemistry, Biology, Biochemistry, Mechanical Engineering, Chemical Engineering, Grain Science, and the Terry C. Johnson Center for Basic Cancer Research. A description of research in the physics department can be found at:

<http://www.phys.ksu.edu/research/condensed-matter.html>

Applications should be sent to **The Condensed Matter Search Committee, 116 Cardwell Hall, Kansas State University, Manhattan, KS 66506-2601** or to softmattersearch@phys.ksu.edu. In addition to a curriculum vita, applications should include statements of research and teaching interests. Candidates should arrange for three (3) letters of reference to be sent as well.

Kansas State University is an equal opportunity employer and actively seeks diversity among its employees. Background check required.



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The University of Alabama at Birmingham (UAB) is one of the premier research universities in the US with internationally recognized and NIH-funded programs in the basic sciences as well as clinical and translational medicine. It is committed to the development of outstanding postdoctoral scientists and has been **consistently ranked in recent years as one of the top ten locations among US universities for training postdoctoral scholars.**

In addition to an exceptional research training environment, UAB offers postdocs:

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UAB is also home to the NIH-funded IRACDA **Mentored Experiences in Research, Instruction, and Teaching (MERIT) Program**, which provides research and teaching experiences to qualified postdocs; for more info, please see www.uab.edu/meritprogram.

Visit our website at www.uab.edu/postdocs and select Postdoctoral Opportunities to view posted positions that interest you.

Where diversity meets science



At AstraZeneca, we're proud of our reputation as a progressive and diverse workplace which values the power of difference. To us, diverse teams are innovative teams, which bring new ideas and fresh thinking to the table.

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AstraZeneca is investigating combinations of biologic and small molecule therapies for the treatment of cancer. These combinations target the tumour directly and some help boost the body's own immune system to induce tumour cell death.



Woods Hole Oceanographic Institution

Fellowships for Postdoctoral Scholars

New or recent doctoral recipients with research interests associated with the following are encouraged to submit scholarship applications prior to January 5, 2016.

Departments - Awards related to the following areas are anticipated: Applied Ocean Physics & Engineering; Biology; Geology & Geophysics; Marine Chemistry & Geochemistry; Physical Oceanography.

Institutes - Each Institute fosters interdisciplinary research addressing critical issues, and we will award a scholarship to support related research: Ocean and Climate Change Institute; Coastal Ocean Institute; Ocean Exploration Institute; Ocean Life Institute

The National Ocean Sciences Accelerator Mass Spectrometer Facility (NOSAMS) will award a fellowship in the development and implementation of new techniques in marine science radiocarbon studies.

A joint USGS/WHOI award will be given to a postdoc whose research is in an area of common interest between USGS and WHOI Scientific Staff. The individual will interact with both USGS and WHOI based advisors on their research.

Awards are competitive, with primary emphasis placed on research promise. Scholarships are 18-months with an annual stipend of \$58,000, a research budget and eligibility for health and dental insurance. Recipients are encouraged to pursue their own research interest in association with resident staff. Communication with potential WHOI advisors prior to submitting an application is encouraged.

Further information may be obtained at:
www.whoi.edu/postdoctoral

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Monterey Bay Aquarium Research Institute

2016 POSTDOCTORAL FELLOWSHIP PROGRAM

Applications for the postdoctoral fellowship program at the Monterey Bay Aquarium Research Institute (MBARI) are currently being accepted. MBARI is dedicated to the development of state-of-the-art instrumentation, systems, and methods for scientific research in the oceans. Ongoing programs in marine robotics, ocean physics, chemistry, geology, and biology as well as information management and ocean instrumentation research and development exist at MBARI. Located in Moss Landing, California at the head of Monterey Canyon, MBARI enjoys convenient access to diverse oceanographic environments. The institute operates research vessels equipped with remotely operated vehicles, autonomous underwater vehicles, and diverse oceanographic equipment. In addition, MBARI operates the MARS seafloor cabled observatory. MBARI is a non-profit oceanographic research institute supported by the David and Lucile Packard Foundation.

Offers will be made to candidates from the fields of biological, chemical, and physical oceanography; marine geology; and ocean engineering. Candidates must be awarded the Ph.D. degree prior to commencing the two-year appointment and start during the 2016 calendar year. Applicants are encouraged to communicate with potential research sponsors at MBARI for guidance on project feasibility, relevance to ongoing research projects, and resource availability (http://www.mbari.org/about/postdoc_mentors.htm).

Application deadline: Wednesday, December 9, 2015

Selected candidates will be contacted in early March 2016.

Application requirements:

1. Curriculum vitae
2. At least three professional letters of recommendation
3. Succinct statement of the applicant's doctoral research
4. Potential research goals at MBARI
5. Supplemental information online form (http://www.mbari.org/oed/jobs/forms/postdoc_form_2016.htm)

Address your application materials to:

MBARI, Human Resources

Job code: Postdocs-2016

7700 Sandholdt Road, Moss Landing, CA 95039-9644

Submit by e-mail to jobs_postdocs@mbari.org (preferred), by mail, or by fax to (831) 775-1620.

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MBARI Welcomes Diversity

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https://www.med.upenn.edu/apps/faculty_ad/index.php/g/d4096

Assistant/Associate Professor of Genetics in the Institute for Biomedical Informatics

https://www.med.upenn.edu/apps/faculty_ad/index.php/g/d4095

To ensure full consideration, applicants are strongly encouraged to apply by November 30, 2015. Please submit a cover letter, curriculum vitae, and a 2-3-page statement of research interests, as well as the names of 3 references.

We seek candidates who embrace and reflect diversity in the broadest sense. The University of Pennsylvania is an EOE. Minorities/Women/Individuals with disabilities/Protected Veterans are encouraged to apply.



HARVARD MEDICAL SCHOOL

DEPARTMENT OF
Biomedical Informatics

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To learn more about these programs as well as postdoctoral fellowships and software engineering opportunities, please visit: <http://dbmi.hms.harvard.edu/>



Washington University in St. Louis

Faculty Positions in Biochemistry and Molecular Biophysics

The Department of Biochemistry and Molecular Biophysics at Washington University School of Medicine invites applications for several tenured/tenure-track faculty positions at the level of Assistant/Associate/Full Professor. Successful candidates will have established a strong record of research. Applicants seeking tenured positions must have a strong record of external funding.

Outstanding individuals working in any area of biochemistry and molecular biophysics are encouraged to apply. The candidate's research should be aimed at addressing fundamental questions related to molecular mechanisms of biological or biomedical relevance. Current research in the department spans a wide range of topics including computational biology, membrane proteins, molecular motors, nucleic acid / protein interactions, protein structure, enzymology and signal transduction. Additional information about the department is available at <http://www.biochem.wustl.edu>. Washington University has a highly interactive research environment with vigorous interdisciplinary graduate and medical scientist training programs.

Applicants should email their curriculum vitae, brief description of their research interests, and contact information of three individuals to the Search Committee at bmbsearch@biochem.wustl.edu. The committee will request letters from these individuals as necessary.

Completed applications will be reviewed on a rolling basis, starting immediately. For full consideration, applications should be received by December 1, 2015.

EOE/Minorities/Vets/Disabilities. The School of Medicine at Washington University is committed to finding solutions to global health problems, including ones that affect minority and disadvantaged populations.

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IOWA STATE UNIVERSITY

Structural Biology Assistant Professor

The Roy J. Carver Department of Biochemistry, Biophysics and Molecular Biology at Iowa State University in Ames, IA has embarked on a transformational expansion of its structural biology research enterprise through a large philanthropic gift from the Roy J. Carver Charitable Trust. This major research initiative in Biomolecular Structure includes long-term investment in new instrumentation, endowed funds for graduate student training, and a series of new faculty hires working at the forefront of any aspect of structural biology.

As part of the faculty positions associated with this initiative, and as part of the interdisciplinary effort across the Iowa State University campus to expand structural biology research, the Department seeks a new tenure-track Assistant Professor to establish a vibrant, externally funded research program of international prominence and participate in graduate and undergraduate teaching.

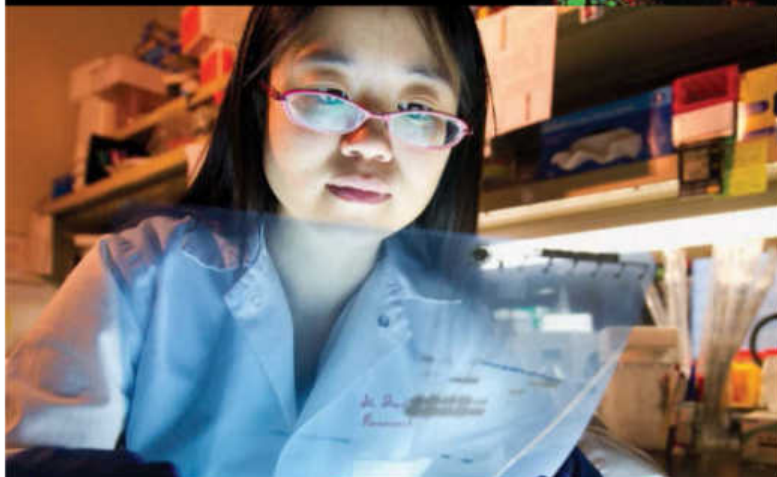
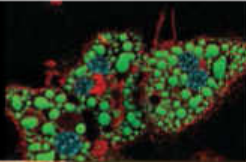
Applicants should have a Ph.D. or equivalent degree, and research accomplishments indicative of the ability to establish an independent research program of national prominence.

To view the entire vacancy #500159 and apply, create an electronic application at www.iastatejobs.com

To guarantee consideration, the applications must be received by December 7, 2015.

Iowa State University is an EO/AA employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, national origin, disability, or protected Vets status.

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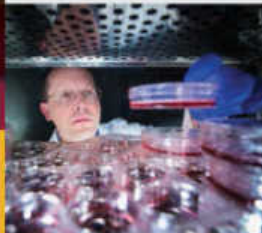
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EDITOR'S PICK



The tautological measure of stuff

From Philip Belben

I think more is going on with new definitions of the “base” units in modern metrology than Stephen Battersby describes (3 October, p 38). Defining the metre in terms of the speed of light tells us that the metre per second, rather than the metre, is now the base unit. The proposal he describes for a new definition of the ampere will actually make the coulomb (charge) the fundamental unit.

That makes attempts to count electrons flowing in a circuit, with all their quantum uncertainty, seem rather misguided; would it not be better to measure charge directly, as we did at school using Millikan’s oil drop experiment? Nettlebridge, Somerset, UK

From Peter Holness

Battersby shows an interesting, nearly tautological connection between units that depend on fundamental constants and constants that depend on those measured units. It would be good, though, to see more light cast on the candela, the unit of luminous intensity. Why is it tied to a monochromatic frequency? Real candles are polychromatic. Hertford, UK

The editor writes:

■ The candela is fundamentally tied to our ability to perceive light, and is defined with reference to the single frequency at which a standard eye is most sensitive.

Memory recovery and therapy

From David Jockelson

Doubtless there are some therapists guilty of instilling false memories (10 October, p 8). But it would be tragic if this occasional bad practice makes us doubt the value of psychological work and the need to listen to victims. The experience of church abuse shows that the pendulum of belief is firmly stuck in denial in many powerful quarters.

I am accredited with the British Association for Counselling and Psychotherapy and am also a solicitor involved with childcare cases. Ironically, I encounter a lot of false memories in my therapy clients. Frequently, they come to me with serious emotional problems but initially tell me they could not be anything to do with their “happy childhoods”. Over the next few sessions, without any pressure or suggestion, they will often disclose events in those childhoods which are clear examples of neglect or abuse.

In my role as a solicitor, I have the painful advantage of seeing intergenerational abuse and dysfunction. I frequently deal with parents who are in complete denial about their own childhood experiences, actually having no memory of it. However, also in the case papers is full evidence of the abuse that person suffered as a child, and which they are often now repeating and inflicting on their children.

London, UK

From Els van Ooijen,
Psychotherapists and Counsellors
for Social Responsibility

You misrepresent the work of psychotherapists. Rather than functioning as “mechanics” who apply a set of techniques, we aim to help people gain a deeper understanding of themselves and their problems. We distance ourselves from dangerous practices such as recovered-

memory therapy. We also doubt that state regulation would be any more effective at preventing this than voluntary regulation.

Bristol, UK

From Ashley Conway,
drashleyconway.com

Most of this article relates directly to the 1990s. It cites old studies by Elizabeth Loftus about the creation of false memories. What does her contrived laboratory research tell us about somebody who has suffered years of abuse?

You promote a myth about hordes of therapists using “recovered memory therapy” after giving patients “strong tranquillisers” – but provide no evidence of even a single case of this happening. This unbalanced and unscientific witch-hunting colludes with the re-creation of a climate of disbelief over the scale of the child sexual abuse problem. London, UK

The editor writes:

■ Our concern for real cases should not make us credulous about all past claims – especially those triggered by dangerous and outdated psychotherapy methods. The National Health Service records of Carol Felstead, whose death in the UK we discussed, show that she was at times “heavily sedated” on diazepam during psychotherapy sessions. And Elizabeth Loftus works on: in 2013 she implanted memories in people with “highly superior autobiographical memory” (doi.org/8nh).

Technology for keeping interest

From Jane Giffould

Manfred Spitzer claims that information technology is of little or no use in education (17 October, p 28). I suggest that he checks out the subject in more detail with actual examples. As a secondary school teacher 25 years ago I had a

physics class of not-very-interested 15-year-olds who would have their bags packed up 5 minutes before the end of the lesson. Looking at force, acceleration and gravity was not going to enthrall them but it was on the exam syllabus.

My technician told me to use the computer. Sceptically following instructions, I put the most awkward lad in charge. That lesson was vibrant with lots of “What would happen if...” It got them interested in the topic and wanting to go further. I had to throw them out at break time.

Halstead, Essex

Do people have children to fit in?

From Laura Re

Your article on having kids does not take into account one crucial factor contributing to happiness: fitting in with your peers (5 September, p 40). My grandmother, talking about the war, used to say: we were poor but it didn’t matter, because everybody was. My aunt once stated that she eventually decided to get married because all her friends had. That’s not mere copycat behaviour: it expresses the need to share similar lifestyles to avoid being left out.

I would guess that an extra reason why 15 to 19-year-olds are the least happy to have children is because most of their peers have none. People over 40 are the happiest, because most of their friends have families. To our social species, no one wants to be the odd one out.

Parma, Italy

Einstein’s proof of general relativity

From Reg Dennick

Pedro Ferreira says that the first “proof” of general relativity was Arthur Eddington’s observation of



"But... this technique is practiced by medics with nothing more than a gloved finger"

Deborah Buffalin comments on a machine to estimate due dates (31 October, p 16), ending: "But, yay, technology."

gravitational lensing in the 29 May 1919 eclipse (10 October, p 33).

But in November 1915 Einstein calculated the anomaly in the precession of the orbit of Mercury, which had never been explained by conventional gravitational theory. When Einstein found that the result of his calculation agreed exactly with observational values he told one of his colleagues he had heart palpitations. This was the moment he knew for the first time that his theory was correct. *Nottingham, UK*

Solutions that distract politicians

From Bryn Glover

While Tim Flannery's "Here comes Plan C" (10 October, p 24) inspires optimism that more new ideas and possibilities for combating climate change are continually being advanced, there is also pessimism at the realisation of how our national and world leaders will receive the notion. Will his proposals not vindicate their assertions that those clever

scientific bods will inevitably find some smart way around climate change, so we can comfortably proceed with business as usual, ignoring all the loonies and lefties who are predicting disaster?

In the UK we are beset with politicians who are not only leading the race to frack for methane, but who apparently believe that we are already making enough energy from the wind. We need to stop consuming fossil fuels as soon as we can, and anything that diverts our fickle politicians' attentions away from that is basically a bad thing.

Kirkby Malzeard, North Yorkshire, UK

Definitely not maybe finding oil

From Simon Kay

As a petroleum geologist engaged in the search for oil and gas, I was encouraged by David Deutsch's words that "the awful secret at the heart of probability theory is that physical events either happen or they don't: there's no such thing

in nature as probably happening" (3 October, p 30). When we plan to drill for oil or gas, management require an estimated probability of success (POS) between 0 and 1.

We concoct POS values based on combining the chances of a number of favourable geological factors existing simultaneously. I always felt that we either would find oil or gas, or we wouldn't. Yet this logic would be frowned upon as unscientific or just laughed at. I feel vindicated.

Bradford-on-Avon, Wiltshire, UK

Greengrocers' ire if you follow this

From Geoff Lewis

Oh dear, oh dear, Gregory Laughlin: you must have caused great consternation among the purveyors of fresh fruit and vegetables. You said that squeezing an object is a handy way to learn about its insides, likening this to testing a melon for ripeness (19 September, p 37).

The right thing to do is to hold this fruit in the palm of one hand

and tap lightly with the fingers of the other hand. If it makes a "hollow" sound it is ripe.

Do not squeeze with fingertips: the small pressure points cause bruising – and shouts of rage from the vendor if you are spotted!

London, UK

Counterintuitive bicycle experience

From Philip Dempster

David Boswell shifts focus from machine to rider when describing how to stay upright on a bicycle (Letters, 26 September). Years ago, an infection substantially affected my inner ear function. Later, improved yet still impaired, I cautiously attempted to ride my bicycle. As if by magic, all sense of impairment vanished. I realised then that inner ear function plays no role in controlling a bicycle. The useful cues are visual.

The inner ear by itself cannot tell whether you are on a corner. This is analogous to a pilot's need for an artificial horizon in cloud. *Concord, California, US*

TOM GAULD

SIR ISAAC NEWTON, 1676



For the record

■ Too chilled out: we meant to refer to "frozen carbon monoxide" on the surface of Pluto (17 October, p 6).

■ Some figures we gave for global production of lithium were for the gross weight of compounds in which lithium is contained: the true weight of lithium extracted in 2013 was 31,300 tonnes (17 October, p 38). And Antofagasta is 350 kilometres to the west of the Salar de Atacama.

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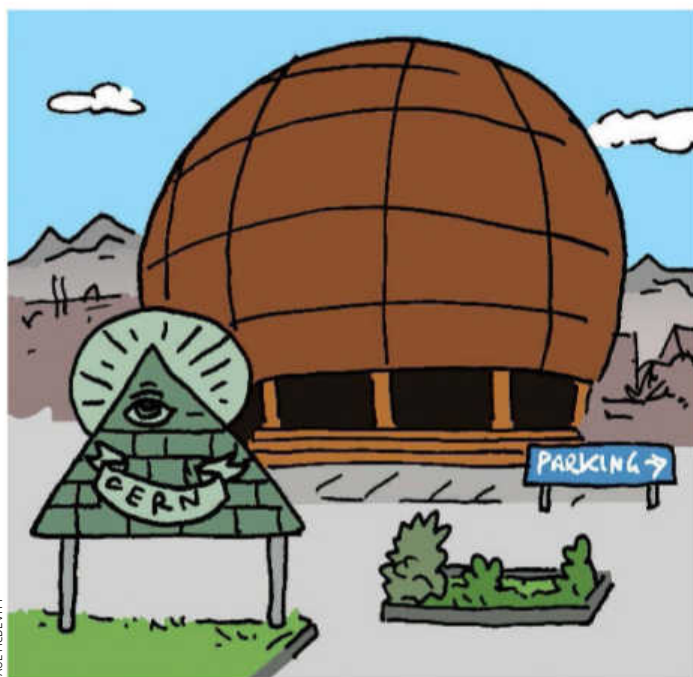


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PAUL MCDEVITT

EARLIER this year, CERN announced that it had discovered a new form of matter (18 July, p 7). Yet even more incredible occurrences inside the supercollider have come to light.

The Express newspaper reports claims that the Large Hadron Collider played an instrumental role in a secret Illuminati plot to open a portal to another dimension and destroy the human race, as revealed by the UK politician who prevented it.

According to "The World's Greatest Newspaper", Simon Parkes, one-time Labour councillor for Whitby, told attendees at a UFO conference that the plan was foiled when he led a "global mind warp" in August, which created a wave of disruptive positive energy and closed the portal.

Perhaps weary of responding to tabloid journalists with incredible exclusives, the CERN press office maintains a surreal list of disclaimers on its website, which includes a denial that the LHC is capable of opening doors to other dimensions. It does

admit that the atom smasher may create harmless quantum-sized black holes. If those do ever grow big enough to threaten the human race, at least we'll know who to call.

MORE trouble with girls, this time experienced by Averil Macdonald. According to the emeritus professor of science engagement at the University of Reading, UK, women oppose fracking because they don't understand it. Macdonald claims that instead of facts, women form their opinions of shale gas extraction based on gut reactions such as maternal instinct, and are "always concerned about threats to their family more than men".

Macdonald shared her thoughts with *The Times* newspaper, in an interview marking her inauguration as chairwoman of UK Onshore Oil and Gas, a lobby group hoping to warm public attitudes toward

the fossil fuel industry.

Macdonald was soon called upon to defend herself against accusations of sexism, but fittingly for a spokeswoman of the fracking industry, only succeeded in digging herself further into a hole. Writing in *The Guardian*, Macdonald blamed the lack of women studying science as the reason behind their failure to get on board with fossil fuels, an accusation EDF Energy broached with only marginally more grace last month (17 October). Like the awkward kid in the classroom, the nuclear and gas industries are desperate to get girls to like them – if only they knew how.

A COUPLE of weeks ago, Feedback "pendantically" discussed the gendered Latin roots of the word puerile (24 October). We're hanging our heads in shame.

FEEDBACK previously discussed *afuncts* – items that are rendered useless by their own overwrought design. We are thrilled to see the field continue to grow in new directions.

The Skarp Razor is a design so far ahead of the cutting edge that it doesn't even have a blade. Instead, a tiny laser beam in the head burns through hairs, giving what the company promises is an incredibly close shave – and perhaps less convincingly, "no razor burn".

The company behind the razor, Skarp Technologies, managed to raise \$4 million in crowdfunding before Kickstarter, the website hosting the campaign, put an end to the whole thing, for the quibbling detail that the product doesn't exist, even as a working prototype. Feedback thinks may be a polite way of saying that Kickstarter doubts it ever will.

The laser razor has since sprouted up on rival crowdfunding site Indiegogo, a host seemingly more ambivalent on such matters, and who the creators say "believe in the Skarp Razor as much as we do".

ELSEWHERE, Sam Floy puzzles over what makes an area "up and coming", that diagnosis beloved of estate agents the world over.

By mapping the ratio of two ubiquitous (and some might say culturally contrasting) London establishments – fast food outlets and coffee shops – he was able to sniff out areas of the city that are affordable, yet whose streets are bathed in the aroma of roasted beans rather than fried chicken (see bit.ly/ns_frymap).

Further plans to map the ratio of bargain stores to bicycle repair shops, and "the street price of coriander", hint that Sam's analysis is firmly tongue in cheek, though Feedback suspects it is now inevitable that the broiler-brewer index will become a staple of estate agent windows.

FINALLY, the long winter nights promise to fly by if *The Times* is to be believed: the newspaper announces results of a study



showing "women are more promiscuous in cold weather". However, hopeful suitors will be disappointed to learn that the test subjects were fruit flies, although the journalist does insist these have "a similar genetic make-up to humans".

A colleague muses: "This explains why, like fruit flies, men begin courtship by vibrating their legs against a woman's head."

"When I first came to this job one of my two questions was: 'Is climate change real?'"
Reassuring words from Andrea Leadsom, UK Minister for Energy and Climate Change.

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Explosive power

Last night, my wife and I were awoken by two loud cracks a second or so apart. The day after, I discovered that the 9-volt battery cell I'd removed from a fire alarm the night before appeared to have exploded (see photo). What might have caused this in a depleted cell, and why two cracks?

■ This photo shows a "battery" in the real sense, being constructed of six 1.5-volt cells connected in series. Some batteries have stacked flat cells but others, like the one pictured, have a three-by-two array of cylinder cells.

Because the battery's terminals are at the same end, a circuit can easily be completed if they come into contact with a metal object – if stored in a metal box, say. The battery has an internal resistance, and heats up when a current flows through it. This causes the water in its electrolyte to vaporise and increase the internal pressure, then... bang!

The first crack would have been the electron-collecting pin being fired from a cell like a bullet from a gun. The second would have been a failure in the casing of the adjacent cell, causing it to be ejected from the battery.

Even a partially depleted battery can supply enough current to heat the metal contacts and internal parts, and also any metal that the battery terminals may touch – and perhaps start a fire. There have been serious injuries to sensitive parts when 9-volt batteries have come into contact



with coins in trouser pockets, completing a short circuit.

David Muir

*Science Department
Portobello High School
Edinburgh, UK*

Cold calling

Vaccination against flu viruses is well established and reasonably successful, especially in high-risk groups such as the very young and elderly. Colds are also caused by viruses and, although they are less virulent, they occur more frequently, making the sum total of sickness and workdays lost comparable. Why is there no vaccination programme for the common cold?

■ The lack of a vaccination for the common cold is not for want of trying. Research into both prevention and cure demonstrates how intractable the problem can be, but the matter has become more urgent now that colds have been

implicated as a cause of asthma.

Smallpox, polio and influenza, which have been countered by vaccination, are caused by a finite number of viruses. The common cold, in contrast, is merely a catch-all term for a wide range of opportunist infections of the upper respiratory tract. Colds are usually ascribed to rhinoviruses, which were discovered as causative agents in 1956. However, work at Cardiff University – which has a dedicated common cold research centre – suggests that perhaps only 30 per cent of colds are caused by these viruses. The other culprits can be coronaviruses and adenoviruses, and some colds may in fact be mild attacks of influenza.

As for rhinoviruses themselves, it is usually stated that there are 99 strains, but the UK National Health Service suggests there are 138 recognised serotypes – and there must be many more waiting to be examined. Each would require its own vaccine. Furthermore, these small strands of RNA both mutate and exchange genetic information, so there will always be novel strains to deal with.

Collectively, cold viruses are among nature's great success stories. A clever pathogen does not destroy its host or immobilise a person to the extent that they cannot walk around and spread their infection. Colds are annoying, and a drain on the economy, but are not seen as enough of a threat to attract the funding given to heart disease and

cancer research; nor are they scary enough to make people modify their behaviour to any great extent. Because they are not taken as seriously as, say, Ebola and H5N1 influenza, colds are the great survivors.

Christine Warman

Hinderwell, North Yorkshire, UK

This week's questions

FRITILLARY FLITTER

What causes butterflies to flutter and flit up and down in the charming way they do?

Dermot Barrett

Kingston, Ontario, Canada

A CHILL WIND

Objects that enter Earth's atmosphere are subject to extreme heat through air friction – so much so that returning spacecraft have to be very well insulated, and rocks and small asteroids burn up. How fast would I have to go to feel heat from air friction? When I'm on my bike going downhill quickly, I can only feel it getting colder and colder.

Ben Cordle

London, UK

SNIFF TEST

If a dog's sense of smell is thousands of times more sensitive than ours, why do they have to get so close to smell each other's bottoms?

Jay Brookhiemer

London, UK

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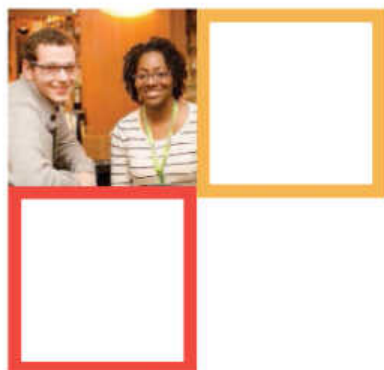
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